GREGG M. SINCLAIR LIBRARY
UNIVERSITY OF HAWAII

HE EAST AFRICAN
AGRICULTURAL
JOURNAL

of

NYA
ANGANYIKA
GANDA AND
ANZIBAR

•

ol. XXV—No. 4

APRIL
1960

•

World List abbreviation: *E. Afr. agric. J.*

IN THIS ISSUE:

RAINFALL, ALTITUDE AND ECOLOGY

SODOM APPLE CONTROL

NEW CULTIVATION EQUIPMENT

MAIZE STORAGE

CASHEW IN TANGANYIKA

Price: Sh. 4

Annual Subscription Sh. 15)
(German D.M.: 10.19)
(U.S. Dollars: $2.41)

THE AMAZING NEW MULTI-PURPOSE

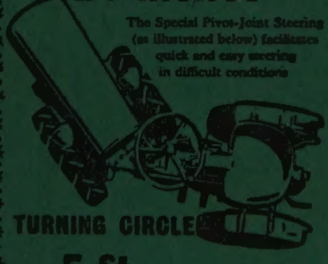
'Holder Tractor'

The most versatile miniature 4-wheel drive Diesel tractor in the world!

TRACK

24 inches

The Special Pivot-Joint Steering (as illustrated below) facilitates quick and easy steering in difficult conditions



TURNING CIRCLE

5 ft.

Holder

PRICE F.O.R. NAIROBI £550

FULL RANGE OF LOW COST MATCHED IMPLEMENTS FOR:-

● *The cultivation and spraying of narrow-planted COFFEE* ● *The cultivation of young TEA* ● *The inter-row cultivation of MAIZE and SUGAR from planting to maturity* ● *The cultivation of SISAL NURSERIES* ● *The one-way ploughing of BENCH TERRACES* ● *The ideal general-purpose tractor for the AFRICAN FARMER* ● *The most economical unit for SMALLHOLDINGS, NURSERIES, PARKS and SPORTS GROUNDS* ● *"FUEL CONSUMPTION 1¼ PINTS OF DIESEL OIL PER HOUR"*

ARRANGE A DEMONSTRATION AND SEE IT AT WORK. YOU'LL BE AMAZED!

Ample Spares

Expert Service

MACHINERY DIVISION

G&R

GAILEY & ROBERTS LTD.

KENYA • UGANDA • TANGANYIKA

(*Incorporated in the United Kingdom*)

THE BARCLAYS GROUP OF BANKS

BARCLAYS BANK LIMITED
BARCLAYS BANK D.C.O.
THE BRITISH LINEN BANK
BARCLAYS BANK (FRANCE) LIMITED
BARCLAYS OVERSEAS DEVELOPMENT CORPORATION LIMITED
BARCLAYS TRUST COMPANY OF CANADA

CANADA

In Canada the Barclays Group is closely associated with the Imperial Bank of Canada which has some 270 branches

This organization, with correspondents throughout the world, is able to offer to those concerned with trade or travel all the services a modern Bank can perform for its customers

TOGETHER WE GROW

Close ties between farmer and Banker are essential in this rapidly growing country. Years of experience in monetary matters dealing with every branch of farming and agriculture, enable us to know your problems. We are here to help and advise you.

THE STANDARD BANK
OF SOUTH AFRICA LIMITED
incorporated in the United Kingdom

Over 800 Branches & Agencies in South, Central & East Africa

WRIGHT RAIN LTD

Have you an irrigation problem?

FREE ADVICE AND ESTIMATES GIVEN BY OUR SPECIALIST STAFF

Irrigation equipment prize winners at the
ROYAL WINDSOR SHOW

WIGGLESWORTH
AND COMPANY (AFRICA) LIMITED
P.O. Box 30092 — NAIROBI — Phone: 20296

Branches
DAR ES SALAAM MOMBASA TANGA KAMPALA

NATIONAL AND GRINDLAYS BANK LIMITED

(INCORPORATED IN THE UNITED KINGDOM)

BANKERS TO THE GOVERNMENT IN KENYA, UGANDA, ZANZIBAR, ADEN AND SOMALILAND PROTECTORATE

PIONEERS OF BANKING IN EAST AFRICA

EVERY DESCRIPTION OF COMMERCIAL BANKING TRANSACTED

For details of the services provided by our branches in East Africa, London and other countries apply to our nearest branch for a copy of our "Rules of Business".

Our Shilling Travellers' Cheques are encashable free of commission throughout East Africa.

MALTING BARLEY COMPETITION

SEASON 1959-60

Growers are reminded:—

1. That the latest date for the acceptance of entries and receipt of exhibits will be April 21, 1960. Entry forms can be obtained from any K.F.A. Depot or from East African Breweries Ltd.

2. That exhibits consisting of one bag of 180 lb. net should be railed carriage paid to the Company at Nairobi ("Two Row" variety only).

3. That each exhibit must be representative of a bulk of not less than 200 bags of barley which have been screened to the same standard as the exhibit.

4. That only one entry of any one variety may be submitted by a grower.

5. That judging will take place at the Maltings on May 14, 1960.

PRIZES:

1st PRIZE £100
2nd PRIZE £50
3rd PRIZE £25

East African Breweries Ltd.
(Established 1922)

NAIROBI MOMBASA DAR ES SALAAM

Associated with
H. & G. Simonds Ltd., Reading, England

Ndurumo Limited

BREEDERS OF PURE BORAN BEEF AND DAIRY CATTLE FOR OVER 41 YEARS

Boran Bull—2½ years old Burua—Supreme Beef Champion, 1958

Stud and herd bulls of proven characteristics for sale. Steers from this farm average 600 lbs. carcass weight, at 4 years, of high grade beef.

★

★

Bred on the semi-arid country of Laikipia without supplementary feeding, these animals can withstand the toughest conditions that East Africa can offer.

Enquiries for foundation stock—

Ndurumo Limited, Box 3, Rumuruti, Kenya Colony

Telephone: Rumuruti 4

INTRODUCING

Nicholas

'PERMACO' TRADE MARK

SI-RO-CO COBALT BULLETS

For Cobalt Deficiency in Cattle and Sheep

Convenient

Reliable

In pasturage on cobalt-deficient soils the present costly, haphazard methods of administering cobalt to cattle and sheep by drenching, top dressing, licks or food supplements are now superseded by a single dose of cobalt.

One dose stops wasting, increases weight in affected animals. Protects healthy stock. Easily administered by balling gun or plastic tube directly into the rumen or paunch, giving slow, even release of cobalt.

Efficiency and Low Cost

Millions of cattle and sheep the world over are now protected by this remarkable discovery which, even in apparently healthy herds, promotes significant weight gain in beef cattle and sheep and increased milk yield from dairy cows.

Available from all veterinary product stockists.

We welcome your application for full details of this major breakthrough in Veterinary Medicine.

A Nicholas Product

ASPRO-NICHOLAS LTD
VETERINARY DIVISION
Slough, Bucks, England

Agents for British East Africa.
BRITISH EAST AFRICA CORPORATION
P.O. Box 664,
Nairobi.

GROWERS OF

BARLEY, MAIZE & WHEAT

In addition to

40% ALDRIN WETTABLE POWDER which is recommended for control of soil pests such as Ol Kalou Beetle, Chafer Grub, Barley Bulb Fly, etc.

and

ALDREX 'M'*
a seed dressing, consisting of aldrin and mercury combined, for protection against soil pest and fungus diseases in Wheat, Barley and Maize.

DIELDREX 'M'* (consisting of dieldrin and mercury) is now introduced to give a complete range of seed dressings for the cereal grower.

**Registered Trade Mark*

SHELL

Available from leading distributors throughout East Africa

The SHELL CHEMICAL COMPANY OF AFRICA LIMITED
(INCORPORATED IN ENGLAND)

Registered users of the SHELL trade mark P.O. Box 30056 NAIROBI Telephone 23015

THE
EAST AFRICAN AGRICULTURAL JOURNAL

Vol. XXV—No. 4 **APRIL, 1960**

Printed and published by the Government Printer, Nairobi

Issued under the Authority of the East Africa High Commission and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue)

Editorial Board: Director of E.A. Agriculture and Forestry Research Organization; Director of E.A. Veterinary Research Organization; Directors of Agriculture, Kenya, Tanganyika, Uganda and Zanzibar; Directors of Veterinary Services, Kenya, Tanganyika and Uganda; Conservators of Forests, Kenya, Tanganyika and Uganda.

Executive Committee: Director of E.A. Agriculture and Forestry Research Organization; Director of E.A. Veterinary Research Organization; The Editor.

EDITOR: J. GLOVER

E.A.A.F.R.O., P.O. BOX 21, KIKUYU, KENYA

Subscription Sh. 15 per volume (Sh. 4 single copy) including postage, payable to the Editor. Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.

The Editor does not hold himself responsible for opinions expressed by contributors.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Double spacing should be used in typescript. Contributors receive 25 prints of their articles free. Additional copies may be obtained on payment if asked for in advance. Prints bear the same page numbers as the original articles in the Journal, except where, to meet a contributor's wishes, prints are supplied before publication has been completed.

Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

CONTENTS

	PAGE
The Rainfall-Altitude Relation and its Ecological Significance in Kenya (*C. G. Trapnell and J. F. Griffiths*)	207
Sodom Apple Control (*H. W. Brzostowski*)	214
Field Observations on Trials of New N.I.A.E. Cultivation Equipment (*J. D. Lea, R. J. Ofield and R. G. Passmore*)	220
Storage of Maize in a Prefabricated Aluminium Silo in Tropical Conditions (*J. C. Davies*)	225
Selenothrips rubrocinctus (Giard) and the floral biology of Cashew in Tanganyika (*M. Bigger*)	229
Control of Infectious Diseases of Animals—II. (*Sir Thomas Dalling*)	235
The Chemical Composition of the Grasses of Kenya—II. (*H. W. Dougall and A. V. Bogdan*)	241
The Artificial Culture of the Edible East African Oyster *Crassostraea cucullata* (Born) (*V. D. van Someren*)	245
The Effects of Four Management Treatments on Temporary Leys (*R. Strange*)	251
Rainfall Interception by a Tropical Forest in Uganda (*B. Hopkins*)	255
The River Fisheries of Kenya—2. The lower Athi (Sabaki) River (*P. J. P. Whitehead*)	259
The Effect of Potassium on the Productivity of Lucerne (*R. G. Poultney*)	266
Concerning the proposed introduction of Nile Perch into Lake Victoria (*G. Fryer*)	267
Sharks of the Western Indian Ocean—III. *Carcharinus menisorrah* (Muller and Henle) (*J. F. G. Wheeler*)	271
Reviews	219, 224, 228, 240, 250, 258
Index to Vol. XXV.	

INDEX TO ADVERTISERS

	PAGE
Barclays Group of Banks	I
British East Africa Corporation	V
Dunlop Tyres	COVER PAGE 4
East African Breweries Ltd.	III
Gailey & Roberts Ltd.	COVER PAGE 2, VIII
May & Baker Ltd.	COVER PAGE 3
National & Grindlays Bank Ltd.	II
Ndurumo Ltd.	IV
Shell Chemical Co. of Africa Ltd.	VI
Standard Bank of South Africa Ltd.	I
Wigglesworth & Co. Ltd.	II

'MALASTAN'

FORMULATIONS OF MALATHION

the latest and safest insecticide

controls:—

Agricultural

Stored Products

Public Health and

Domestic and Livestock

Pests

- ★ **MALASTAN** Emulsifiable Concentrate
- ★ **MALASTAN** Dispersible Powder
- ★ **MALASTAN** Dust
- ★ **MALASTAN** Solutions and Concentrates for Pogging and Atomising

AN SDC PRODUCT OF THE STANDARDISED DISINFECTANTS COMPANY LTD., LONDON

DISTRIBUTED THROUGHOUT EAST AFRICA BY

G&R **GAILEY & ROBERTS LTD.**

KENYA • UGANDA • TANGANYIKA

THE EAST AFRICAN AGRICULTURAL JOURNAL

THE RAINFALL-ALTITUDE RELATION AND ITS ECOLOGICAL SIGNIFICANCE IN KENYA

By **C. G. Trapnell and J. F. Griffiths**

(*Received for publication on 20th August, 1959*)

The findings which are set out here have arisen from an investigation of vegetation types in Kenya south of 1° N. Lat. and west of 38° E. Long. The purpose of the investigation was to co-ordinate ecological zones which had been worked out in the several provinces by various members of the Kenya Department of Agriculture, as a sequel to the work of Edwards on this subject (*see* Edwards, 1940, Edwards and Bogdan, 1951). The conception behind these zones was one of a climatic series of vegetation types. As is well known, southern Kenya is subject to marked orographic variation of rainfall. There is a general tendency for rainfall to increase with altitude, and vegetation changes proceed correspondingly in series from lower, hotter and drier conditions to higher, cooler and wetter conditions. It was found in the field study, however, that these sequences varied greatly in character in different parts of the region. There is not in fact in this region a single climatic series of vegetation types in a uniform zonal arrangement. There are at least three distinct sequences involving different series of vegetation types.

CLIMATIC SERIES OF VEGETATION TYPES

It is not the purpose of this paper to give a description of the vegetation of southern Kenya. It will be sufficient here to state the main heads of the vegetation types involved. In a populated region a vegetation grouping which is to be employed for correlation with climatic factors must of necessity combine primary or climax types with secondary types which have been derived from them as a result of clearing, cultivation and other human activities. It is also necessary to subdivide the extensive savanna and bushland types. Upon this basis the main categories of vegetation which occur may be designated as follows:—

1. Montane moorland.
2. Montane open grassland.
3. Montane bamboo forest.
4. Montane sclerophyll forests and associated types—
    - (*a*) Montane sclerophyll forest (Podo. and cedar).
    - (*b*) Derived montane bushland and scrub-grassland.
    - (*c*) Derived *Tarchonanthus* bushland.
5. Moist montane forests and associated types—
    - (*a*) Moist montane forests.
    - (*b*) Moist montane scrub-grassland and cultivation savanna.
6. Moist intermediate forests and associated types—
    - (*a*) Moist intermediate forests.
    - (*b*) Moist intermediate cultivation savanna.
7. Dry intermediate forests and associated types—
    - (*a*) Dry intermediate forests (semideciduous).
    - (*b*) Intermediate dry forest scrub and cultivation savanna.
8. Upland evergreen (sclerophyll) bushlands and associated types—
    - (*a*) Upland evergreen bushlands.
    - (*b*) Derived *Tarchonanthus* bushland and *Acacia* scrub.
9. Intermediate semi-evergreen thicket and associated types—
    - (*a*) Intermediate semi-evergreen thicket.
    - (*b*) Intermediate thicket-scrub and cultivation savanna.
10. Broad-leaved savanna-woodland and savanna types—
    - (*a*) Moist *Combretum* savanna types.
    - (*b*) Mid-*Combretum* savanna and evergreen-bush transition types.

   (*c*) Dry *Combretum* savanna and thorn-bush transition types.

11. Thorn-woodland and savanna types—
    (*a*) Montane *Acacia* woodland and savanna.
    (*b*) Upland *Acacia* woodland and savanna types.
    (*c*) Transitional *Albizia-Acacia* savanna.
12. Thorn-bushland types—
    (*a*) *Commiphora-Acacia* bushland and thicket.
    (*b*) Mixed *Acacia* bushlands.
    (*c*) Transitional desert *Acacia* bushlands.
13. Desert thorn-scrub types (mainly outside the area considered here).

In this bare outline altitude and rainfall designations have been used for convenience, with allowance for extension of terminology to coastal lowland types. The more specialized types of impeded drainage areas have been omitted. It is with the distribution of the major climatic types that we are concerned.

This distribution may be best described by beginning with the central highlands about the Rift Valley. Disregarding the montane moorland vegetation of the higher tops the sequence in this case proceeds from montane grassland with forest outliers or flanking areas of bamboo forest, down through several variants of montane sclerophyll forest to upland evergreen bushland or to derived *Tarchonanthus* and *Acacia* mixtures. These in turn give way to upland *Acacia* savanna types and lower dry *Acacia* bushland. The main types involved are Nos. 2, 4 (*a-c*), 8 (*a-b*), 11 (*b*) and 12 (*b*). Occurrences of montane *Acacia* vegetation (11*a*) in the vicinity of Nakuru and of the Eldoret plateau and certain exceptions in the Baringo-Elgeyo rift area are referred to subsequently. The general vegetation sequence of this region probably has affinities with parts of Ethiopia, but may also find analogies to the south in a restricted portion of northern Tanganyika. The area which it occupies is referred to here as the Rift Highlands sector.

Flanking this sector on either side are two regions occupied by very different vegetation sequences. In the Lake Victoria region to the west the series include types which are in part related to those of Uganda. The highest abutments facing the lake carry, or used to carry, moist montane forest, now skirted extensively by montane *Acacia* woodland or savanna. The forest must at one time have existed in the Kisii highlands but has since been replaced here by moist montane scrub-grassland and cultivation savanna. These types give way in the main to moist *Combretum* savanna; but in the most favourable areas to moist intermediate forest and derived cultivation savanna. From both of these, with diminishing rainfall, there are transitions to a lower-lying cultivated zone towards the lake shore which at one time carried intermediate semi-evergreen thicket. The sequence involves types 5 (*a-b*), 11 (*a*), 6 (*a-b*), 10 (*a-b*) and 9 (*a-b*). This sector sloping to Lake Victoria is referred to for convenience as the Western Decline.

A parallel sequence, but with differences in vegetation composition is found on the broad slope towards the Indian Ocean to the east of the Rift Highlands sector. This begins again with moist montane forest on the higher flanks of Mount Kenya and the Aberdares, with cultivation savanna derived either from this or from related forest. It passes downwards into other types of cultivation savanna associated with remnants either of moist intermediate forest or of dry intermediate forest according to local rainfall conditions. These give way respectively either to mid-*Combretum* savanna or to a *Combretum*—evergreen bush transition which passes into dry *Combretum* savanna. The *Combretum* zone finally gives way to dry *Commiphora-Acacia* bushland. The types involved are Nos. 5 (*a-b*), 6 (*a-b*), 7 (*a-b*), 10 (*b-c*) and 12 (*a*). Properly speaking there is a dual series, but it will be sufficient for the present to treat this as one sector, the Eastern Decline, with affinities in adjoining parts of Tanganyika.

Naturally enough this broad three-fold division involves some marginal transition types. The only important exceptions, however, have been found in the Baringo-Elgeyo rift region extending north from Nakuru. The vegetation types found in this part answer mostly to the normal Rift Highlands sequence but depart from it in some respects. The divergences include the belts of montane *Acacia* vegetation (11*a*) already noted in the Nakuru area, local *Combretum* savanna and *Combretum*-evergreen bush transitions (10 *b*) near Solai and Ravine and on the east flank of the Elgeyo valley and the transitional *Albizia-Acacia* savanna (11 *c*) of the Emening area south of Baringo. There are also certain local differences in forest vegetation. Some of these occurrences could be regarded as outliers of vegetation types proper to the Western and Eastern Declines, but they were considered too local in their distribution to constitue a separate regional division.

The boundaries of the three main divisions are shown against topography on Map 1. The vegetation sequence of the Western Decline is contained by a line which passes from the west flank of the Cherangani range (to the east of Kitale), circuits west of Eldoret, passes through the western portion of the Tinderet and Mau Forests and thence south-west near Bomet (old Sotik) along the western side of the Chepalungu Forest. The line is somewhat arbitrary between route intersections, notably in the Mau Forest and in its northern and southern extremities. At its northern end it has been drawn to exclude a *Rhus-Heeria* variant of montane evergreen bushland found north of Eldoret, which is possibly of a transitional nature. In the Mau Forest it includes marginal areas of bamboo whose status is at present uncertain. In its southern portion it includes the impeded drainage areas of the Sotik region. Its projection is not yet known south of Kilgoris.

The line containing the sequences of the Eastern Decline runs along the north side of the Nyambeni range (north-east of Mount Kenya), just north of Meru, over the east flank of Mount Kenya, around Nyeri and thence down the rim of the Aberdares and Kinangop through Limuru to Ngong and Nairobi. From Nairobi it doubles back to Ol Doinyo Sabuk and thence resumes a less definite southerly course through the Machakos hills. This line is again somewhat arbitrary between route intersections, more particularly between Mount Kenya and the Aberdares where further field work is needed, and may again include marginal bamboo forest on the Kinangop rim. It is necessarily a compromise in the complex vegetation of the Machakos hills, where it has been drawn to the limits of *Combretum* vegetation.

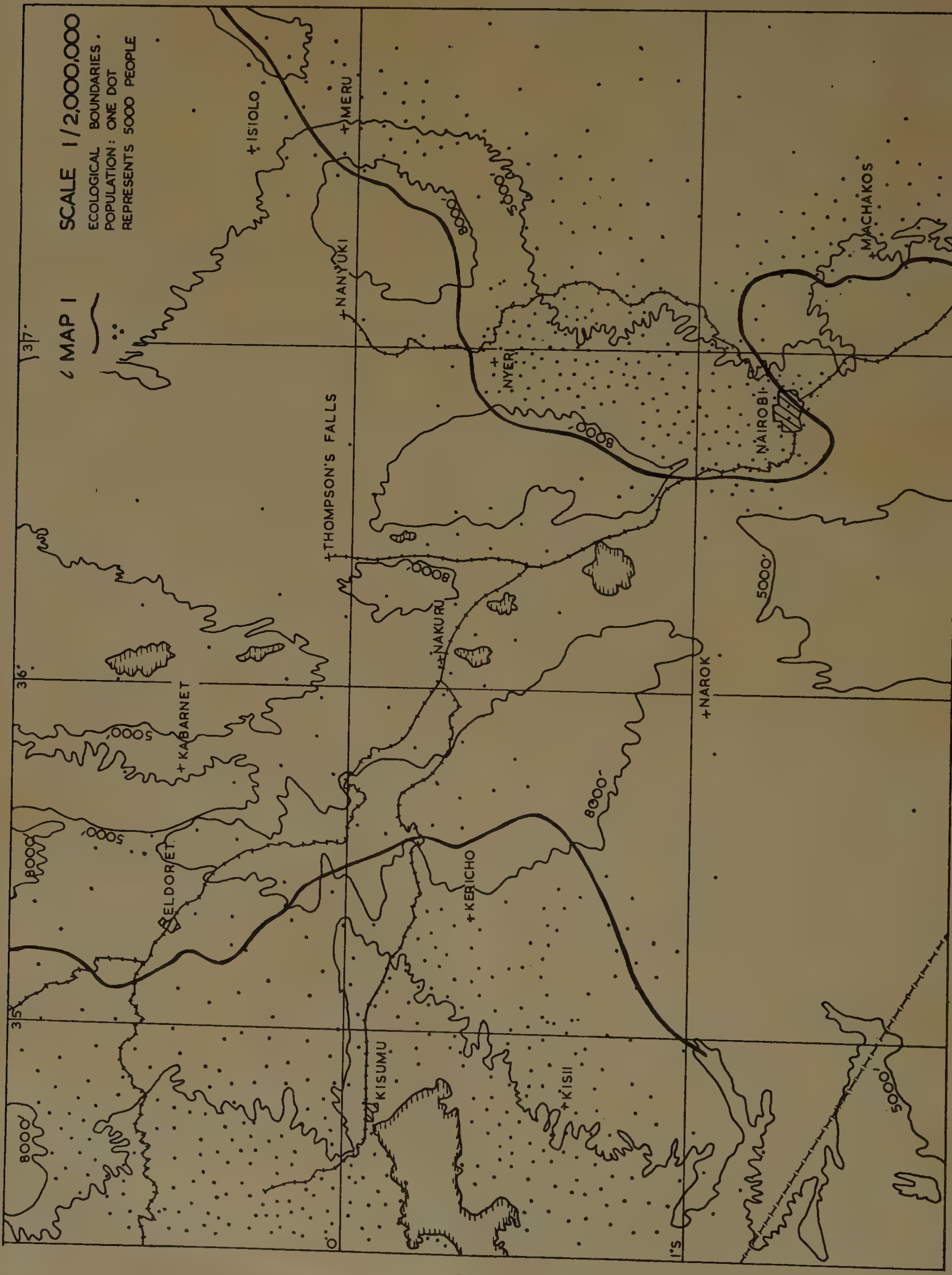
Both lines, however, represent the nearest approximations possible on present data. Between them lies the distinct vegetation region referred to as the Rift Highlands sector, with certain divergences in the Baringo-Elgeyo area.

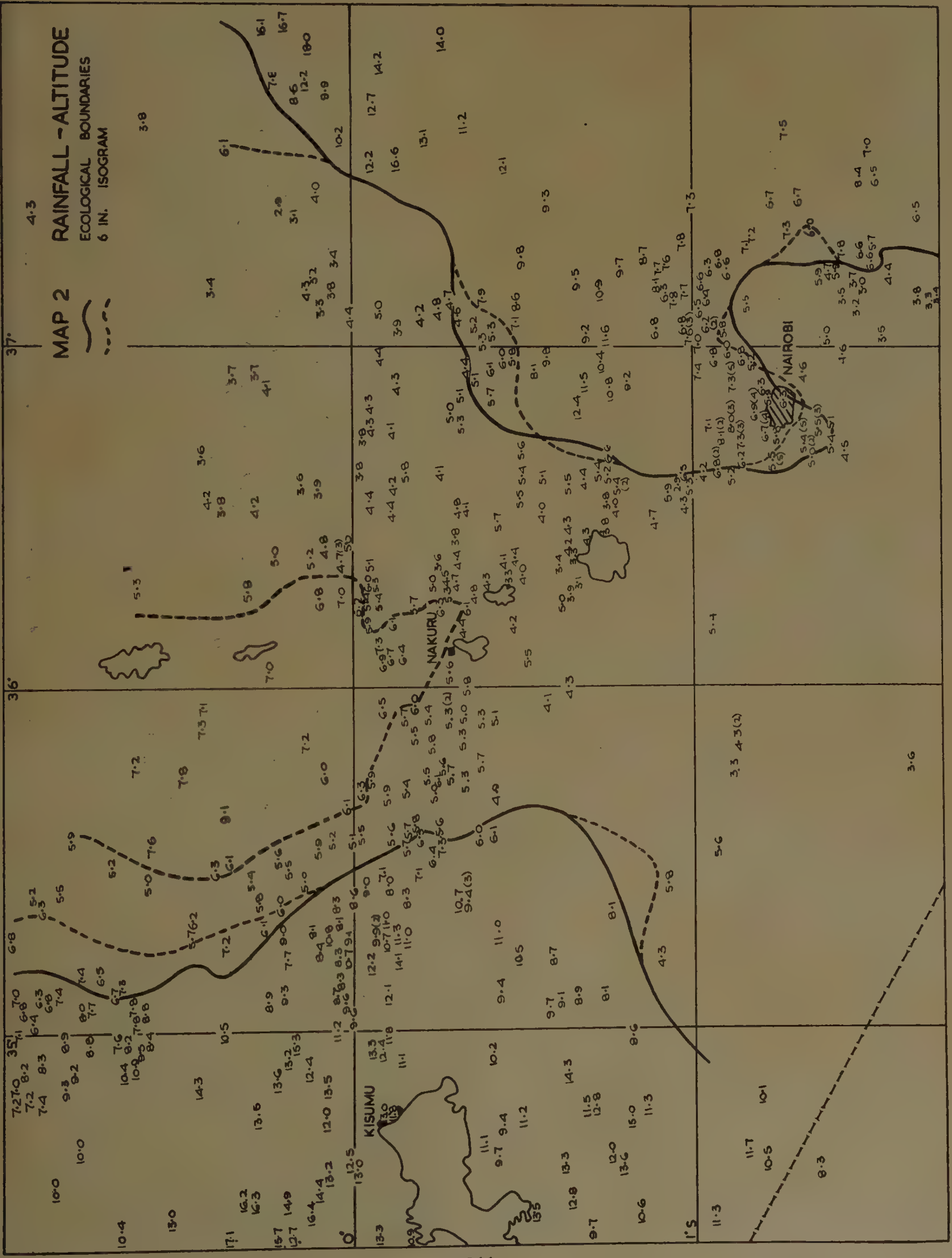
The Rainfall-Altitude Ratio

These vegetation lines were drawn without reference to climatic data. In fact they bear no relation either to contours or to isohyets considered separately. It seemed probable, however, that the differentiation into three major vegetation sequences could be related to differing combinations of rainfall and altitude. This supposition was tested by applying a factor, the number of inches of rainfall per thousand feet of altitude (i.e. the rainfall divided by a thousandth of the altitude), to representative rainfall recording stations within each of the regional divisions. The sample figures indicated that stations on the Eastern and Western Declines enjoyed high rainfall ratios, falling jointly between 6 and 16 inches per thousand feet, whereas those in the Rift Highlands sector had only 3 to 6 inches. The only major exception was an enclave answering to the Baringo-Elgeyo rift region, where the factor rose to between 6 and 8. This correlation was then fully checked at the East African Meteorological Department. Computations were produced for all recording stations of 8 years standing or more, involving in all some 550 stations. The figures were plotted initially on a map scale of 1/250,000. The results are shown on Map 2, in which the rainfall-altitude ratios are shown against the lines dividing the three vegetation sectors. Bracketed figures on this map indicate the number of stations involved in places where averages have had to be shown for lack of space.

It will be apparent at once that the ecological dividing lines agree remarkably nearly with the isogram for the 6 in. ratio. That is to say, stations on the Eastern and Western Declines do in fact enjoy high rainfall ratios, falling generally between 6 and 16 inches per thousand feet, whereas those in the greater part of the Rift Highlands sector have only 3 to 6 inches. Divergences of the 6 inches isogram from the vegetation limits are shown by broken lines. The divergence north of Eldoret lies in the *Rhus-Heeria* form of evergreen bushland already referred to. Those south of Nyeri and about Nairobi are in areas where the vegetation division has been drawn on the limits of dry intermediate forest (*Croton-Brachylaena*). These forests occupy a marginal position and overlap the 6 inches isogram. One or two other minor divergences are dependent on single stations.

Apart from these instances the only major exception in the correlation is the enclave shown in the Baringo-Elgeyo region where the factor rises to between 6 and 8, and in one instance to 9. Corresponding departures in the vegetation from the normal Rift Highland sequence have already been noted here. The drier *Acacia* types of vegetation, such as types 11 (*b*) and


MAP I
SCALE 1/2,000,000
ECOLOGICAL BOUNDARIES.
POPULATION: ONE DOT REPRESENTS 5000 PEOPLE
37°
36°
35°
0°
1°S
ISIOLO
MERU
NANYUKI
NYERI
NAIROBI
MACHAKOS
THOMPSON'S FALLS
NAKURU
KABARNET
ELDORET
KERICHO
KISUMU
KISII
NAROK
8000'
5000'


MAP 2
RAINFALL - ALTITUDE
ECOLOGICAL BOUNDARIES
6 IN. ISOGRAM
NAIROBI
NAKURU
KISUMU
37°
36°
35°
0°
1°S

12 (*b-c*), occur in this area under higher rainfall than elsewhere but with a pronounced one-season distribution. The montane *Acacia* belts in the vicinity of Nakuru occupy a marginal position about the apex of this enclave. The correlation otherwise is extraordinarily close.

The meteorological effect of this finding is to demonstrate a significant climatic break which may be referred to as the "Rift Highlands rain gap". Reference to previous papers in this journal (Kenworthy and Glover, 1958, and Griffiths, 1958) will show that this break lies across the meeting of differing seasonal regimes, those of the Lake Victoria and upper Nile basin regions on the one hand and of the ocean hinterland on the other. Their influences may be reflected in the differences in vegetation between the Eastern and Western Declines. Between them is a marked fall-off in orographic rainfall which may be partly of a rain-shadow character. Rain-shadow effects are easily demonstrated along the rim of the Eastern Decline, where drier vegetation occurs consistently on the western flanks of mountains and hill ranges. The in-borne moisture from oceanic air is precipitated on the eastern faces. Higher precipitation on western faces, on the other hand, is indicated by the vegetation in parts of the Western Decline, and locally in the Baringo-Elgeyo enclave. The possible influence on air movements of the conformation of the land surface in the intervening Rift Highland region also calls for consideration. The outcome, however, is clearly a region of different rainfall-temperature relations to those on either side of it.

It should be made quite clear that the rainfall-altitude ratio is employed to denote differences in rainfall-temperature combinations in an area in which temperature recording stations are few and far between.* It has been demonstrated by Kenworthy at E.A.A.F.R.O. (1957) that temperature in East Africa is closely related to altitude, the relationship following the equation $T = 82 - 2.9 A$ (corr. coeff. 0.93), where T is the mean annual temperature in degrees Farenheit and A is the altitude in thousands of feet. Data from 130 temperature stations in Kenya give the equation $T = 86.4 - 3.6 A$ (corr. coeff. 0.95), the two equations being very comparable over the altitude range of the region considered here. It is not, however, intended to imply here that rainfall and temperature, through influence on evaporation, are operating as compensating factors in vegetation distribution. In fact this study has provided instances to the contrary. Cedar forest, for example, is found in this region under rainfalls of up to 50 or possibly 55 inches at 8,000 to 9,000 feet, but at its lower limit near the 6,000 feet contour subsists on rainfalls down to about 25 inches. Where the rainfall exceeds 35 inches at this lower level of altitude it does not appear to exist. The rainfall-altitude ratio, therefore, is not intended as an integration of climatic factors. It is simply an expression of differences of combination.

The significance of the 6 inches isogram is probably capable of explanation. It appears to coincide with the limits of distribution of certain types of vegetation which in general require a rainfall from about 30 inches upwards—the broad-leaved savanna and moist forest types of the Eastern and Western Declines. Rainfalls of this order are obtainable at the altitudes ordinarily prevailing in equatorial Africa, which in the main falls below 5,000 feet. But in areas where the rainfall-altitude ratio falls below 6, rainfalls of 30 inches and over can only be attained by ascending to altitudes in the range of 5,000 feet upwards, with a proportional temperature fall-off. This implies a combination of temperature and rainfall outside the usual run of African conditions, and it is not unnatural that other types of vegetation should have held their place, with semi-temperate affinities in the higher examples. These are the sclerophyll types characterizing the Rift Highlands region. These types, on the other hand, tend to disappear where decreasing altitude or proportionally increased rainfall bring about a return to the more normal combinations of the equatorial regime.

Additional Considerations

It is quite possible that these dividing lines between "normal" and "abnormal" combinations of climatic conditions may be found to have wider significance. In drawing them, for example, a suggestive parallel was noted in the distribution of human population. The population densities shown in the Kenya Atlas (1959) have been included in Map 1 for this reason. Population distribution, naturally, is subject to a variety of controls. Both the past history of tribal movements and more recent settlement restrictions in the White Highlands need to be taken into consideration. (The effect of the latter is relevant for the map representation up to 1948, the date of the last census.) It is interesting, none the less, to observe how closely the main concentrations of population have followed the Eastern and Western Declines. These are agricultural populations, which have been dependent on normal tropical cereal crops, nowadays chiefly maize with local sorghum. The possible influence of rainfall-altitude relations upon the pattern of their distribution may be worth some consideration.

---

*As an index of these differences it is the equivalent of Stefanoff's (1930) "Index of hygric continentality", the use of which was perhaps unduly criticized by Moreau (1938).

On both the Eastern and the Western Declines a normal total rainfall of say 35 inches is readily obtainable without ascending to undue altitudes—i.e. favourable rainfalls can be obtained without loss of warm conditions. But in the intervening Rift Highlands region in order to obtain a total rainfall of 35 inches or over it is necessary to ascend to anything from 6,000 to 9,000 feet, an altitude range in which, apart from human preferences, lowered temperatures begin to be retarding for the more tropical cereals. Main-crop maize is, of course, grown by Europeans around 6,000 feet in the montane *Acacia* belts near Nakuru, and even at 7,000 feet in the Eldoret region, where there is now a large production. It has also been pushed up to high altitudes by African squatter populations and, under pressure of increasing population, in the reserves on the Eastern Decline. The very prolonged growth period at higher levels, however, is no aid in seasonal drought hazards or to the reaping of a satisfactory subsistence crop. In the original pattern it would seem likely that either maize or sorghum and millet cultivation occupied the regions of more favourable rainfall-temperature combinations, while the Rift Highlands region remained vacant save for the incursions of pastoral tribes.

The rainfall-altitude ratio, of course, represents only one aspect of a climatic regime. Where annual crops, especially, are concerned, as in this instance, it is necessary to have regard also to differences in seasonal distribution of rainfall, markedly contrasted to the east and west of the Rift, and to associated differences in the reliability of the rains. The papers already cited on this subject should be referred to. As shown by Kenworthy and Glover (1958), the region west of the Rift is the more favourably placed in this respect, tending as it does towards a one-season distribution with a greater degree of reliability. This factor affects the pattern of maize cultivation. With some woody vegetation, on the other hand, it is quite conceivable that a two-season distribution, such as is found in the eastern region, may be of consequence. The evidence outlined in this paper, however, indicates that in dealing with Kenya vegetation the primary grouping of climatic regimes is to be sought in the combination of rainfall and temperature conditions involved. With the scarcity of temperature-recording stations this is most readily expressed through the rainfall-altitude relation.

SUMMARY

The vegetation types of southern Kenya have been found to fall into three separable climatic series in the range between higher and moister and lower and drier conditions. The lines of division between these sequences have been drawn on a small-scale map. Their effect is to show that southern Kenya is divisible into three main sectors, referred to as the Western Decline, the Rift Highlands, and the Eastern Decline. This three-fold division is found to be associated with differing combinations of rainfall and altitude, expressed in terms of the number of inches of rainfall per thousand feet of altitude. Computations for 550 stations show that the Eastern and Western Declines enjoy high rainfall-altitude ratios, falling generally between 6 and 16 inches per thousand feet, whereas the greater part of the Rift Highlands sector has only 3 to 6 inches per thousand feet. Exceptions in the Baringo-Elgeyo rift region are commented on. The lines of division otherwise correspond remarkably closely to the 6 inches isogram. This relationship may be regarded as a first approximation to one of rainfall and temperature. Its significance is discussed with reference to temperature-altitude relations and to its general bearing on bioclimatic interpretation in Kenya.

REFERENCES

E. Afr. agric. and for. Res. Org. (1957). Record of research, 18.

Edwards, D. C. (1940). *J. ecol., 28,* 377.

Edwards, D. C., and Bogdan, A. V. (1951). Important Grassland Plants of Kenya, Nairobi, Pitman.

Griffiths, J. F. (1958). *E. Afr. agric. J., 23,* 179.

Kenworthy, Joan M., and Glover, J. (1958). *E. Afr. agric. J., 23,* 267.

Kenya Atlas (1959). Survey of Kenya, Nairobi.

Moreau, R. E. (1938). *J. ecol., 26,* 467.

Stefanoff, B. (1930). Versuch zur darstelling einer parallelen klassifikation der klimate und der vegetation-typen, Sofia.

SODOM APPLE CONTROL

By H. W. Brzostowski, Tanganyika Agricultural Corporation, Pasture Research Station, Kongwa, Tanganyika

(Received for publication on 22nd August, 1959)

In the Kongwa area the following species of sodom apple are common: *Solanum delagoense* Dunal, *S. campylacanthum* Hochst., *S. delagoense* Dunal. Var. *obliquum* (Damm) Bitter and *Solanum* sp.

It is a perennial, well rooted shrub 4 to 5 ft. high. Root washing has showed that roots penetrate the soil up to 8 ft. in depth. The plant produces rhizomes which grow horizontally 2 to 6 in. under the soil surface. The length of these rhizomes varies, but by the end of the growing season they often reach 6 ft. or more.

The rhizomes produce new shoots which grow fast. First flowers appear when the plants are 24 to 32 in. high and they are soon followed by the first berries. The time between the emergence of new shoots and the flowering stage is from one and a half to three months.

As sodom apple is a perennial plant, with strong and deep-growing roots and with well-developed foliage, it eradicates neighbouring annual grasses in a comparatively short time.

The life cycle of annual grasses at Kongwa is short, three to four months, and any soil moisture unused by them is available to the sodom apple. Pastures consisting of annual grasses need not necessarily be overgrazed to become infested with sodom apple. Annual grasses are not the climax of vegetation in this area. It is only natural that they are defeated by sodom apple, which plays a part in the plant succession, returning land to the dense deciduous thicket which is the climax of vegetation in the Kongwa area and many other parts of East Africa.

On pastures with vigorous perennial grasses appearing as a natural cover, or artificially established, sodom apple has no chance to spread, and if it does so it is almost certainly due to bad management.

Sodom apple is propagated by seeds and rhizomes. The initial infestation of clean land usually starts with seeds, although rhizomes or other parts of the plant can be brought from infested fields to a clean one by farm machinery and implements.

The fruit of sodom apple is a berry and experience at Kongwa has shown that it may contain anything from 40 to over 600 seeds. Investigation has shown that the seed has a long dormancy period. Seeds collected nearly four years ago are still in the dormancy stage. There is no doubt that animals and birds take part in their dissemination.

Four patches, each of 100 ripe berries, were placed in different parts of a field. After one month only the outer parts of the berries were left. Later, droppings of animals and birds were investigated. It appears that seeds of sodom apple are common in animal droppings and germination tests have shown that, for example, seeds taken from ostrich's excrement had 33.3 per cent of germination capacity. Seeds were taken from fresh droppings in May, 1959, and the above-mentioned germination capacity was recorded on the second day of the trial. The remaining seeds did not germinate during the next ten days and afterwards went rotten. It shows that seeds after passing through the alimentary tract of ostrich and probably other birds are able to germinate after a very short period.

If seed falls near the mother plant it has little chance to grow as the mother plant is surrounded with new shoots which are derived from the buds of its rhizomes. A young plant which grows from seed is surrounded by 20 to 50 young shoots towards the end of the second growing season. The clump of sodom apple is then about 6 to 12 ft. in diameter. Each season the area occupied by a clump increases steadily by about 2 to 4 ft. in diameter, but after burning or cutting the diameter of a clump increases rapidly, about 12 ft. during a season. Clumps of sodom apple grow into big patches and finally patches join together. Observations over a period of four years showed that on a pasture containing mostly annual grasses, sodom apple established itself to a variable extent. Estimations on sample areas showed a percentage cover varying from 47 to 71 per cent.

Mechanical Method of Sodom Apple Control

Slashing.—Many trials have been carried out. The sodom apple was slashed with bush slasher and mown at different times of the year and at different stages of plant growth. In some cases it was slashed four times during the year. This treatment is valueless as a control measure since it cannot eradicate sodom apple and in many cases it actively encourages growth of new shoots. Four paddocks which were grazed during the growing season in three successive years and were mown after each grazing had in the third year five times higher population of sodom apple than in the first year. The experiment was sampled for the first time on 28th December, 1955, for the second time on 15th December, 1956, and for the third time on 13th January, 1958. Plant population was estimated as follows: 5,220, 14,440 and 25,630 plants per acre respectively. In the same period the control paddocks had 9,320, 18,900 and 32,140 plants per acre. The plant population was recorded on permanently marked sample plots 100 × 3 ft. each.

Ploughing and Crushing.—One month before the beginning of the rains a plot was ploughed 6 to 8 in. deep with a 504 Massey Harris plough. The operation was done in order to let the rhizomes dry out. Another plot was crushed with a B VIII Holt brush breaker. Sample plots 100 × 5 ft. each were permanently marked in each area and the plant population was recorded before the field was ploughed or crushed.

The plant population was recorded for the second time nine months after the operation was carried out. Table 1 shows the results obtained from these trials.

Table I.—Plant Population of Sodom Apple per Sample Before Ploughing or Crushing, and 9 Months Later

Ploughed—Oct., 1958			Crushed—Oct., 1958		
Sample	20–9–58	24–6–59	Sample	8–10–58	24–6–59
No.			No.		
1	307	178	1	94	211
2	579	312	2	160	204
3	168	216	3	921	611
4	79	80	4	212	241
Mean	283	196	Mean	346	316
Per cent	100	69	Per cent	100	91

As is seen in Table 1 the results are disappointing. Despite these negative results, even heavily infested fields can be mechanically cleaned of sodom apple, but ploughing, discing, harrowing and hand picking of roots and rhizomes must be repeated a number of times, following which the land should be sown with a fast-growing plant and again be well cultivated between the rows.

Burning.—This measure is effective against small trees and shrubs if it is applied at the proper time, but it does not help in controlling sodom apple. The flames will destroy sodom apple stems if the plants are not growing very thickly and if among them there is still some dry grass to burn, but the heat cannot kill roots and rhizomes. If the plants are dense there is nothing to be burnt among them and the fire destroys only the grass which is growing around the edge of the patches. After burning and long before annual grasses can appear, sodom apple produces numerous new shoots.

Comparing the effect of burning with other treatments the results are as follows:—

Treatment	*Per Cent of Live Plants*
Control	100.0
Burnt at the end of dry season	69.6
Cleaned by hand hoe (rainy season)	55.2
Sprayed with "Fernimine" (rainy season)	16.1

Grazing.—An experiment has been carried out with grazing at different times of the year, combined with mowing and burning treatments. After three years this experiment was abandoned as none of the treatments could check the plant. The mean area of 28 paddocks (acres) covered by sodom apple reached 56.7 per cent. The potential yield of fresh annual grass from sodom-apple-free pastures for the season up to February 1957, was 101 cwt./acre, but the actual yield was 45 cwt./acre.

The Use of Herbicides

During the past five years many experiments with herbicides have been carried out and the results obtained have been very promising. So far, it seems that a herbicide is the best method for controlling sodom apple, but the following main points should be noted:—

(1) Sodom apple should be sprayed at the proper stage of growth.

(2) The right herbicide should be used.

(3) The correct rate of herbicide should be applied.

(4) The proper dilution should be used.

(5) The spraying machine should be in good order.

(6) Spraying should be performed with great accuracy.

Experiments have been carried out with 2,4-D amine, 2,4-D ester and 2,4-D/2,4,5-T mixture. These herbicides work slowly. Two to three months elapse from the time of spraying to death of the plant. In two to three hours after spraying the first symptoms of wilting are visible and this usually starts from the top of the plant.

If spraying is done well the leaves should not be burnt. Burnt leaves are usually due to a too high concentration of spray. It has been observed that sodom apple plants which had their leaves burnt with herbicide started to produce new leaves shortly afterwards. The effect of 2,4-D amine and 2,4-D/2,4,5-T on sodom apple is shown in Table II.

"Fernimine" 2,4-D amine was applied at the rates of 25 oz., 30 oz. and 35 oz. per acre, diluted in water and sprayed at 100 gallons per acre. "Finopal" 2,4-D/2,4,5-T was applied at the rates of 18 oz., 24 oz. and 30 oz. of acid equivalent per acre diluted in water and sprayed at 40 gallons per acre. The plot size for spraying was 1/100 acre and 1/200 acre for plant recording. Each treatment had four replications. The plant population was first estimated on 4th February, 1957, before the first spraying; for the second time on 15th May, 1957, before the second spraying, and for the third time on 16th January, 1958, which was about six weeks after the rainy season had started. At that time any sodom apple plants which were still alive should have produced new shoots and fresh leaves.

As is shown in Table II, after the first spraying, over 80 per cent of the plants were killed. After the second spraying the plots sprayed with 30 and 35 oz. per acre of 2,4-D amine and plots sprayed with 18 and 24 oz. per acre of 2,4-D/2,4,5-T mixture were free of sodom apple. Application of 2,4-D amine at the rate of 25 oz. per acre was not sufficient.

In 1958/59 the experiment was carried out with 12 different products. Sodom apple was sprayed twice and the results obtained are shown in Table III. All products were diluted in water and applied at the rate of 100 gallons spray per acre. Each treatment had four replications and the plot sizes were as in the 1957/58 experiment. Plots were sprayed on 29th April, 1958, and resprayed on 10th February, 1959. Respraying usually requires one quarter or one third of the spray used for the first spraying.

The above-mentioned results are very good, and each product can give a good result if applied in proper time and in the right manner.

Stage of Growth.—The result of spraying depends to a great extent on the stage of growth of sodom apple at the time the operation is carried out. Very young plants which are growing fast show less susceptibility to translocated herbicides and after very early spraying new plants emerge.

TABLE II.—NUMBER OF LIVE PLANTS OF SODOM APPLE BEFORE AND AFTER FIRST AND SECOND SPRAYINGS

Treatments	Plant Population				
	Before Spraying	After First Spraying		After Second Spraying	
	Plants/acre	Plants/acre	Per cent	Plants/acre	Per cent
"FERNIMINE" 2,4-D AMINE—					
25 oz./acre	132	20	14·8	9	6·6
30 oz./acre	185	3	1·6	0	0·0
35 oz./acre	161	9	5·3	0	0·0
"FINOPAL" 2,4-D/2,4,5-T—					
18 oz./acre	172	9	4·4	0	0·0
24 oz./acre	156	5	3·2	0	0·0
30 oz./acre	179	15	8·1	1	0·3

TABLE III.—EFFECT OF SPRAYING OF SODOM APPLE WITH 12 DIFFERENT PRODUCTS

Treatment (Product)	Active ingredient	Plants/Plot	
		28–4–58	1–6–59
	oz./acre		
(*a*) Weedar 64-amine 2,4-D	32	89	1
(*b*) Weedone 2,4,5-T and 2,4-D.	32	78	1
(*c*) Weedone LV 4 ester 2,4-D.	24	76	Nil
(*d*) Weedazol (Aminotriazole) 50%.	64	83	Nil
(*e*) Ferminine, amine 2,4-D	30	74	Nil
(*f*) Palormone D, amine 2,4-D.	30	67	Nil
(*g*) Palormone B, ester 2,4-D.	25	54	Nil
(*h*) Phordester, ester 2,4-D	15	81	Nil
(*i*) Shell D, ester 2,4-D ..	20	73	7
(*j*) Finopal, ester 2,4-D/2,4,5-T.	30	81	Nil
(*k*) Spontox, ester 2,4-D/2,4,5-T.	28	67	4
(*l*) Weedone 2,4,5-T ..	24	77	1
(*m*) Control	Nil	83	74

The late spraying, in the dry season, is completely impractical. Table IV shows the results obtained with spraying of sodom apple during the dry season and in December and January of the rain season. Palormone D was used at the rate of 30 oz. active ingredient per acre: plot sizes as before. Table IV shows that spraying of sodom apple during the dry season and in the early rainy season is only wasting time and money. Spraying in January shows a practical response to herbicide. It appears that the best time for spraying is when the majority of plants are in their flowering stage. In an experiment the best result was obtained when sodom apple was burnt or slashed about a month before the rainy season started and sprayed when the new plants reached about 18 to 30 in. in height and were in their flowering stage. They were all more or less at the same age and it was easy to spray them.

TABLE IV.—EFFECT OF HERBICIDES ON SODOM APPLE DURING THE DRY SEASON

Date Sprayed	Rainfall	No. of plants/plot before spraying	Plant Population 10–6–59	
			plants/plot	per cent
12–5–58	0·51	127	90	70·9
3–6–58	0·06	127	112	88·2
4–7–58	Nil	135	150	110·7
5–8–58	Nil	177	158	89·0
4–9–58	Nil	184	130	70·7
6–10–58	Nil	133	188	140·8
7–11–58	Nil	158	240	150·7
11–12–58	4·85	168	198	118·1
7–1–59	5·89	155	27	17·4

Plants 18 to 30 in. high usually have about 19 leaves with a total surface area of about 200 square inches. This surface of leaves is big enough to absorb a sufficient amount of herbicide to kill the whole plant.

If plants are not slashed or burnt, the best time for spraying is when the plants are covered with new leaves as occurs shortly after the beginning of the rainy season. Towards the end of the rainy season cuticularization of sodom apple leaves increases, and probably, as a result, the resistance of the plants to herbicides increases. Spraying during long dry spells in the rainy season and spraying during the dry season is not recommended, although the plants have leaves and some may be in flower. Respraying, where it is necessary, can be carried out two to three months after the first spraying, but if the first spraying was late in the season it is better to postpone it to the beginning of the next rainy season.

An experiment was carried out in 1958 with the purpose of investigating the influence of 2,4-D amine and 2,4-D ester on sodom apple applied at different stages of growth.

The treatments were as follows:—

Plots B and C were sprayed with Palormone D 2,4-D amine and plots B^1 and C^1 were sprayed with Phordester 2,4-D ester. B and B^1 plots were sprayed on 5th February, 1958, and plots C and C^1 on 11th April, 1958. Four replications were carried out. The plot size was 1/100 acre for spraying, 1/200 acre for plant recording. Palormone D was applied at the rate of 30 oz. active ingredient in 100 gallons water per acre and Phordester at the rate 18 oz. active ingredient per acre.

TABLE V.—NUMBER OF PLANTS OF SODOM APPLE BEFORE AND AFTER SPRAYING

Treatments	Date of spraying	Plant Population Number per Plot			Per cent
		3–2–58	10–4–58	9–9–58	
A ..	Control	93		95	102·0
B ..	5–2–58	98		2	1·5
B^1 ..	5–2–58	96		3	2·6
C ..	11–4–58		95	26	26·8
C^1 ..	11–4–58		86	23	26·9

As is seen from Table V, 2,4-D amine and 2,4-D ester applied in February gave very good results, but they were less satisfactory when the herbicides were applied in April. These two herbicides have a very similar effect on sodom apple and both are equally good. Respraying was necessary and it was carried out in February, 1959.

Effect of Weather Conditions.—Spraying on very hot days necessitates higher rates of spray to obtain a proper wetting of sodom apple. When spraying has been carried out just before rain poor results have usually been recorded. Spraying during a strong wind gives an uneven distribution of spray. In spite of these difficulties there are many suitable days when spraying can be carried out with good results.

The influence of the time of day on spraying of sodom apple was investigated. Two plots, 1/200 acre each, taken at random, were sprayed every three hours during the day. "Kildine 50" 2,4-D amine was applied at the rate of 30 oz. active ingredient in 100 gallons of water per acre.

The experiment was laid down on an area which had been burnt in November and had a very high population of sodom apple.

The last rainfall before spraying, 1.16 in., was recorded on 17th January (spraying was carried out on 21st January), and the first rain after spraying, 0.84 in., was recorded on 27th January. On 21st January the sunshine duration was about 6½ hours, distributed as follows: two hours between 7 a.m. and 10 a.m.; 2½ hours between 10 a.m. and 1 p.m., and two hours between 1 p.m. and 4 p.m. After 4 p.m. the sky was overcast. The day was not windy.

The temperature and humidity were recorded half an hour before spraying and half an hour after each spraying. The figures shown in Table VI represent the mean for two readings.

Table VI

Sprayed at	7 a.m.	10 a.m.	1 p.m.	4 p.m.	7 p.m.
Temp. °F...	65·5	74·5	83·2	84·0	70·7
Humidity %	100	77	57	57	89

Spraying was carried out with the same knapsack sprayer and by the same person, using half a gallon of spray on each plot.

Table VII shows the results obtained from these sprayings.

In each treatment over 90 per cent of the sodom apple plants have been killed. It is a very good result and it would be difficult to obtain any better results with one application of herbicide. The best result was spraying at 4 p.m., but as all results are good, spraying in similar conditions can be carried out throughout the day.

Table VII.—Results of Spraying of Sodom Apple at Different Times of the Day

Time of Spraying	Plant Population per Plot		
	Before Spraying 20–1–59	After Spraying	
		10–6–59	per cent
7 a.m. ..	562	49	8·7
10 a.m. ..	436	19	4·4
1 p.m. ..	457	32	7·0
4 p.m. ..	504	14	2·8
7 p.m. ..	547	21	3·8

Sprayers.—The spraying of small patches of sodom apple can be carried out with a knapsack sprayer, but bigger areas heavily infested require tractor-mounted or trailer-mounted sprayers. A high volume sprayer is recommended with which 100 gallons of spray can be applied per acre. Although chemicals can be translocated from one part of the plant to another it is very important to obtain a good saturation of the foliage with the spray.

Good results have been recorded with lower rates of spray such as 10, 20 and 40 gallons per acre, but with low volume the results depend more on climatic conditions during the spraying operation and on the stage of growth of the sodom apple. When spraying on a bigger scale is carried out, a higher rate of spray (100 gallons per acre) is desirable.

Cost of Spraying.—The main factor which governs the cost of spraying is the cost of the herbicide. When buying in bulk the price per gallon is usually substantially reduced, but still amounts to about 80 per cent of the cost of spraying. As an example the cost of spraying of 609 acres is shown below.

The sodom apple was slashed with a home-made bush slasher in November and sprayed in January. About two-thirds of the area was covered with sodom apple. The amine of 2,4-D was used and the product contained 5 lb. of active ingredient per gallon. Three pints of the herbicide were applied per acre. The price per gallon is Sh. 30, or Sh. 3/75 per pint. Low volume sprayers, 20 gallons/acre, were used.

Items	*Sh.*	*Per cent*
2,4-D amine	4,526	80.6
European supervision and transport	433	7.7
Petrol, oil and lubricants	358	6.6
Cost of labour	244	4.3
Water (Sh. 7 per 1,000 gallons)	55	1.0
Total ..	5,618	100.0

The first spraying of the 609 acres cost Sh. 5,618, or Sh. 9/22 per acre of pasture. The result was good and respraying should not have cost more than Sh. 2 per acre. The first and second spraying would cost Sh. 11/22 or, say, Sh. 12 per acre.

The cost of spraying, of course, will vary from farm to farm and from field to field.

SUMMARY

During the past five years work has been carried out at the Pasture Research Station with the purpose of finding the best method to eradicate sodom apple on pastures. Two main methods were tested, mechanical and chemical. The first appears to be unsatisfactory but the second one is much more promising.

The best results have been obtained when old sodom apple plants were burnt, slashed or crushed and thereafter sprayed with 2,4-D when the young shoots reached the flowering stage.

ACKNOWLEDGMENTS

The author is much indebted to Mr. R. E. T. Hobbs, the Chairman of the Tanganyika Agricultural Corporation, for his kind reading of the manuscript and encouragement, and to Dr. A. C. Evans, the Chief Scientific Officer of the Tanganyika Agricultural Department, for helpful suggestions and criticisms of the manuscript. Thanks are also due to Mr. A. Owen, Agricultural Officer, Pasture Research Station, Kongwa, for his kind help in the preparation of this paper, and to Mr. A. G. Bates, Mechanical Engineer of this Station, for construction of the bush slasher and his help with the slashing of the sodom apple.

REVIEWS

ATLAS OF KENYA, First Edition, 1959, compiled by the Survey of Kenya, Nairobi, Kenya, 44 maps, outline of physiographic features and gazetteer. Price Sh. 50.

This is the long awaited Atlas of Kenya. It covers the physiographic, economic and biogeographic aspects of the Colony and Protectorate and it illustrates their climate. It should appeal to everyone in Kenya and to all those who have business with Kenya. At its price it is a great bargain.

The greatest praise must be given to the Director and staff of the Survey of Kenya for its production and especially to Mr. McArthur Davis who had the task of collecting the material as well as editing and compiling the gazetteer. There are inconsistencies and discrepancies of course, but none that cannot be amended in future additions. Perhaps the most noticeable inconsistency is the wide variation in colour of margins which range from heavy black through brown to grey and a notable discrepancy is the different extent of forest indicated in the contiguous areas of the Laikipia and Nanyuki regions of the Rift Valley and Central Province. Such a discrepancy is not necessarily the fault of the compiler who can only draw the attention of specialists to it. Indeed, more than anything, it illustrates the value of the Atlas for here side by side are shown two slightly different stories which must be reconciled.

It is said that comparisons are odious, but one naturally thinks also of the Tanganyika Atlas, the elder brother of this. The Kenya Atlas compares very favourably with the Tanganyika Atlas and both together give a very satisfactory summary of the geography, geology, climatology and economics of most of East Africa. When can we have the Uganda Atlas to complete the picture?

J.G.

THE COOL GREENHOUSE AND CONSERVATORY, by Deenagh Goold-Adams, published by Faber & Faber, London, 1959, 180 pages, 38 illustrations. Price 25*s*.

This book will interest amateur gardeners in Britain, or any country enjoying or suffering a similar climate.

It will have little appeal in East Africa, a number of the plants suggested as glasshouse subjects are treated as weeds here, Lantana and Impatiens to name only two.

The book is well arranged and printed, though for 25*s*. one might have expected the excellent photographs to be reproduced in colour.

W.B.M.

FIELD OBSERVATIONS ON TRIALS OF NEW N.I.A.E. CULTIVATION EQUIPMENT

By J. D. Lea, R. J. Ofield and R. G. Passmore, Cotton Research Station, Namulonge, Uganda

(*Received for publication on 23rd July, 1959*)

A new method for the mechanized cultivation of annual crops in semi-arid areas of East Africa has been suggested by Hawkins (Cashmore & Hawkins, 1957; Hawkins, 1959). It is based on tied ridge cultivation and includes ridge splitting and furrow ripping instead of ploughing, and combined cultural operations, such as ridging and planting, or ridge splitting and planting. The main purpose of this approach is to reduce the cost of mechanical cultivation, and to save time, an important factor in the semi-arid tropics where the growing season is normally short.

Special equipment for the new system was designed and constructed at the National Institute of Agricultural Engineering and the first East African trials took place at the Cotton Research Station, Namulonge, Uganda, in 1958. Namulonge is in the bimodal rainfall belt of East Africa and there are two cropping seasons each year. Groundnuts and maize are the main crops of the first rains (February to May) while in the second rains (August to December), cotton is the principal crop and beans are a subsidiary crop. The cropping cycle at Namulonge is thus very different from that of the semi-arid unimodal rainfall areas of East Africa, for which the new equipment is designed. Nevertheless the preliminary trials have indicated that the new methods will be of practical value on a mechanized cotton farm in an area with a bimodal rainfall distribution, as well as in the more arid regions.

The farming system developed at Namulonge is described in a paper by Hutchinson and Prentice (1959). The Nalumuli farm runs on a 3:3 rotation as follows:—

First rains	*Second rains*
1st year—maize	cotton
2nd year—groundnuts	beans
3rd year—maize	cotton
4-6th year — *Chloris gayana* ley	—

On Kirimantungo farm the arable phase is continued for six years before going down to *Chloris gayana* ley. In the 3:3 rotation cotton follows a quick maturing maize (K8). Early planting of cotton is of great importance in obtaining high yields (Manning, 1949), and the usual procedure on the farm is to re-ridge as soon as the cobs are harvested from the standing crop. The stalks are then laid in the furrow and cotton is sown on the old maize ridges in mid-June (Stephens, 1954). Planting conditions are normally dry at this time of the year, and establishment is much better on old consolidated ridges than on newly formed ridges (Prentice, 1957). Tied ridge cultivation is standard practice for all crops grown on the station. The normal sequence of field operations carried out on the farm are listed in a following section, together with the proposed sequence using the new methods.

The equipment tested by the N.I.A.E. at Namulonge consisted of a specially designed toolbar and clamps, chisel rippers, lister bottoms and bedder sweeps, unit planters, and ridge tying units based on the pattern designed by Mr. H. G. Farbrother. The toolbar and clamps, and the ridge tying units are not in commercial production; the remaining items are standard S.A.F.I.M. equipment. A 45 h.p. wheeled tractor was used in the tests. The implements in normal use on the farm at present are disc and mouldboard ploughs, two tandem disc harrows, a disc ridger, a bobbin roller, and a four row planter. The disc ridger is used both for the initial ridging operation and for inter-row cultivation.

RIPPING, RIDGE SPLITTING, PLANTING AND INTER-ROW CULTIVATION

The trials began in February, 1958, on eight acres of land cleared from bush in 1956. A number of tree roots still remained in the ground, but the ripper shear pins and friction bolts on the ridging bodies functioned satisfactorily and there was no serious damage to equipment during the trial. The field was down to cotton in 1957, and the stalks were removed by hand and burnt after harvest. The weed cover, which was more or less continuous but not more than 1 ft. high, consisted mainly of annual grasses and scattered *Commelina sp.* The first operation, on 27th-28th February, was ripping the old furrow bottoms, and three chisel rippers mounted on the N.I.A.E. toolbar were used. The soil at this time was hard, but a penetration of about 1 ft. was maintained. On another field, ripped when the soil was moister, the working depth was 18 in. The tractor was mainly in first gear; in second gear traction was generally satisfactory but wheel slip and straining occurred in patches of subsoil exposed during clearing.

Ripping was followed by ridge splitting on 5th-6th March. Four No. 2 (the larger pattern) lister bottoms, each with an attached tie ridging unit, were used for this operation. The tractor worked in first gear. Substantial ridges and ties were formed, and the weeds were well buried. As the old ridges were rather hard large clods were pushed up along the new ridge. A good surface for planting was, however, prepared by going over the ridges once with a bobbin roller. On another field, where the old ridges were extremely dry and compacted, very large hard clods were thrown up in the ridges and planting even after rolling would have been impracticable. Thus at Namulonge timing will be of importance in the application of the ridge splitting technique. Normally ridge splitting would best be carried out after rain, but difficulties may arise when, for example, ridge splitting is necessary during a dry spell in the planting period to control weeds. Ridge splitting was tested again in one of the soil chemist's experiments. This time fertilizer and manure were placed by hand along the furrow bottom, and the ridges were then split back. The manure and fertilizer are thus placed in the new ridge directly below the plant.

Ridge splitting was followed by planting with four unit planters. An important new feature of the N.I.A.E. planting equipment is that the two tie-ridging units (to remake the ties pressed down by the tractor wheel) are fixed directly to the toolbar between the planter units. On the old type of planter, hand lifted tying units are attached to the rear press wheel support bar and this arrangement is unwieldy and requires two extra men. A uniform and evenly spaced stand of maize was obtained but the groundnut plant population was lower than desirable even though the fastest sprocket combination was used. This was in part due to the breaking of kernels in the seed can, and a more sensitive feed mechanism would be an advantage.

Inter-row cultivation was carried out with five bedder sweeps and tie ridging units. These sweeps work particularly well when the soil is friable, but for re-ridging and weeding when the soil has hardened the disc ridger gives better results. The draught of the discs is, however, more than twice as great as the sweeps (Hawkins, 1959) and only two rows can be worked at a time. On the whole the sweeps seem the better of the two types of ridging body.

COMBINED RE-RIDGING AND PLANTING

Trials on cultivating cotton by the new methods followed in the second rains. In addition to the operations described previously the combined re-ridging and planting of cotton was tested on land that had been under maize. The maize was first cut by hand and then stooked on the field boundary. This was followed soon afterwards by the combined weeding and planting operation using three planter units separated by lister bottoms and tie ridging units. An excellent stand of cotton was obtained on about 20 acres sown by this method on 12th-13th June, and most of the weed growth in the furrows was killed.

COMBINED RIDGE SPLITTING AND PLANTING

Under dry or partly dry conditions combined ridge splitting and planting was not successful because the planter shoes tended to ride over clods thrown up by the ridging bodies. On land that had been disced and ridged, or where the soil in the old ridges was soft and friable, better results were obtained, though a few days after rain the dry surface soil is thrown into the centre of the ridge leaving the moist soil on the outside. The combined ridging and planting of beans was successfully carried out on land that had been previously ploughed and disced.

DISCUSSION

The preliminary tests have indicated that the new methods are of practical value at Namulonge. The proposed mechanized operations for the maize-cotton groundnuts-beans sequence are set out, together with those used in the present system, in Schedule 1. Three alternative rotations are given in Schedule 2: these are likely to be more difficult to manage than the maize-cotton groundnuts-beans rotation which is particularly well suited to a double cropping regime from the point of view of timing and practicability. The new methods do however offer a means of overcoming at least some of the difficulties of timing. In all sequences ripping precedes ridge splitting just before the first rains. If necessary ripping could also be carried out in the growing crop as a means of improving rainfall infiltration in the furrow bottom.

SCHEDULE 1.—SEQUENCE OF MECHANICAL OPERATIONS FOR THE MAIZE-COTTON GROUNDNUTS-BEANS ROTATION

		Conventional method	New method
YEAR 1	First rains..	Plant maize Inter-row cultivate Re-ridge	Plant maize Inter-row cultivate
	Second rains	Plant cotton Inter-row cultivate Plough Disc Ridge Roll	Re-ridge and plant cotton Inter-row cultivate Rip furrows Split ridges Roll
YEAR 2	First rains..	Plant groundnuts Inter-row cultivate Harvest groundnuts Plough Ridge Roll	Plant groundnuts Inter-row cultivate Harvest groundnuts Re-ridge or split Roll
	Second rains	Plant beans Inter-row cultivate Plough Disc Ridge Roll	Plant beans Inter-row cultivate Split ridges, first time Rip Split ridges, second time Roll
No. of operations		21	18

SCHEDULE 2.—SEQUENCE OF MECHANIZED OPERATIONS (HAWKINS SYSTEM) FOR THREE CROP ROTATIONS

Sequence A.	Groundnuts-cotton	groundnuts-cotton
Sequence B.	Maize-cotton	groundnuts-cotton
Sequence C.	Groundnuts-cotton	maize-beans

Sequence A	Sequence B	Sequence C
Plant groundnuts Inter-row cultivate Harvest groundnuts Re-ridge Roll Plant cotton Inter-row cultivate Rip Split ridges Roll Plant groundnuts Inter-row cultivate Harvest Re-ridge Roll Plant cotton Inter-row cultivate Rip Split ridges Roll	Plant maize Inter-row cultivate Re-ridge and plant cotton Inter-row cultivate Rip Split ridges Roll Plant groundnuts Inter-row cultivate Harvest groundnuts Re-ridge Roll Plant cotton Inter-row cultivate Rip Split ridges Roll	Plant groundnuts Inter-row cultivate Harvest groundnuts Re-ridge Roll Plant cotton Inter-row cultivate Rip Split ridges Roll Plant maize Inter-row cultivate Re-ridge and plant beans Inter-row cultivate Split ridges, first time Rip Split ridges, second time Roll
No. of operations: 20	17	18

When maize or groundnuts follow the quick maturing bean crop, dense weed growth usually develops in the three-month period between the two crops, and ploughing or two to three ridge splitting operations would be needed to keep the weeds under control. Two alternative crop sequences, excluding beans, are given in Schedule 2. Sequence A is continuous groundnuts-cotton while in Sequence B the land is divided equally between groundnuts and maize in the first rains and the whole area is down to cotton in the second rains. In Sequence C a long term maize followed by the late sown beans replaces the short term maize of the other sequences. The total number of mechanized operations over a two-year period for the conventional methods is 21 compared with 17 to 20 for the new methods. The number of mechanized operations in Sequence A is more than in Sequence B and C because in the groundnuts-cotton sequence the ridges are broken down at harvest, and new ridges have to be put up and rolled before the cotton is sown. It is important to bear in mind that the difference in input of tractor hours between the new and conventional methods is likely to be greater than that indicated by a straight comparison of the total number of mechanical operations. This is because ploughing takes about 1.6 hours per acre whereas the input for ripping is about 0.7 hours per acre. More precise data on the difference in inputs and returns between the conventional and new methods will not, however, be available until the current trials have run for another season.

With large seeded crops such as cotton, beans and maize a smooth seedbed of fine tilth is not necessary, and these crops can be established on quite rough ground. Large, loose clods along the top of a "fluffy" ridge are, however, a disadvantage. If planting is carried out soon after rain these clods are split by the planter shoe and a satisfactory crop stand can be obtained. As soon as the clods harden penetration of the planter shoe is irregular, and an uneven stand results. In addition, under dry conditions, crop establishment, particularly of cotton, is difficult on a soft ridge. It seems likely, therefore, that rolling with the bobbin roller will sometimes be necessary after ridge splitting or re-ridging following groundnuts, both to consolidate the new ridge and to form a more even surface for planting.

The main economic advantages of the new methods are the low tractor input per acre and a reduction in the number of implements required on the farm. This means that each tractor can deal with a larger area of land, and on a big farm it would mean fewer tractors and implements and thus a substantial saving in overhead costs. It follows, therefore, that ley farming would probably be unsuitable because of the comparatively high number of tractor hours required to break and prepare the ley for planting. Or at least, the arable phase before resting might have to be of long duration, perhaps six to ten years.

This then raises the question of the maintenance of productivity with fertilizer and FYM. The application of fertilizer presents no problem, and it would either be placed below the plant, or in bands alongside the row using standard fertilizer cans. In 1956 placement of phosphate under the ridge gave a better yield than placement on the ridge (Le Mare, 1957) and in experiments in Tanganyika Hagenzieker (1956) obtained large increases in yields of maize and soya bean by placing fertilizer at 1 ft. depth. Deep ripping along the furrow bottom offers an easy and practical method of applying fertilizer at depth since standard fertilizer cans, driven by a central paddle wheel or the outer toolbar wheel, can be fitted to the toolbar above the ripper shanks. The application of FYM on a large scale is more difficult, though this is tempered in some parts of East Africa by a long residual effect (Peat, 1953; Jameson and Kerkham, 1958). Thus if the response to manure persists for five years only 40 acres need be treated each year on a farm of 200 acres arable. This means that enough permanent grazing would have to be set aside to provide about 200-400 tons of manure each year. In this type of farming the cost of making and transporting the manure might be high. Once the manure has reached the field, however, its incorporation in the soil by ridge splitting is comparatively easy and inexpensive.

At Namulonge the responses to fertilizer and manure have not been very large, though fields cultivated for ten* years are apparently now showing some decline in productivity. It seems likely therefore that in the future the application of FYM and fertilizer may be necessary. The yield of the first cotton crop following a three-year *Chloris* ley may be as much as 30 per cent higher than the yields on land under permanent cultivation, but this "new land" effect does not appear to persist for very long (Le Mare, 1958: Lea and Passmore, 1958). The possibility of prolonging the beneficial effect of the ley by using elephant grass instead of *Chloris*, by applying nitrogen fertilizer to the ley, or by including a legume with the grass, is being investigated.

---

* Four fields of about four acres each are under permanent cultivation at Namulonge. On the remainder of the farm a three-year ley is included in the rotation.

SUMMARY

The first East African trials on the Hawkins system of mechanized cultivation took place at Namulonge, Uganda, in 1958. Basically this new approach to farm mechanization in the tropics consists of ripping instead of ploughing, ridge splitting, and combined cultural operations. The main purpose is to save time and reduce costs. Furrow ripping to 12-18 in., ridge splitting, inter-row cultivation, and combined re-ridging and planting were successfully carried out on a field scale. When ridge splitting under very dry conditions large clods are turned up in the ridge and this can make planting difficult. Normally it will be possible to overcome this by careful timing but difficulties may occasionally arise when, for example, ridge splitting is necessary during a dry spell in the planting period to control weeds. In general, however, the preliminary trials suggest that the new methods are likely to be of considerable practical value on a large mechanized cotton farm.

ACKNOWLEDGMENTS

We are indebted to Mr. H. L. Manning, Director of the Cotton Research Station, Namulonge, and Mr. H. G. Farbrother, for their helpful interest in this work.

REFERENCES

Cashmore, W. H., and Hawkins, J. C. (1957). Tillage equipment and soil conservation. *J. Instn. Brit. agric. Engrs. 13*, 3.

Hagenzieker, F. (1956). Studies on subsoil placement of fertilizer at Urambo, Tanganyika. *Emp. J. exp. Agric., 24*, 109.

Hawkins, J. C. (1959). The N.I.A.E. in East Africa. *Emp. Cott. Gr. Rev., 36*, 35.

Hutchinson, J. B., and Prentice, A. N. (1959). The planning of a large farm for the Namulonge Cotton Research Station in Uganda—the development of the farm and the planning of a crop rotation. *Emp. Cott. Gr. Rev., 36*, 82.

Jameson, J. D., and Kerkham, R. K. (1959). The maintenance of soil fertility in Uganda. (1) Soil fertility experiment at Serere. In Press.

Lea, J. D., and Passmore, R. G. (1958). Namulonge Progress Report, 1957/58. Empire Cotton Growing Corporation, London.

Le Mare, P. H. (1958). Namulonge Progress Report, 1957/58. Empire Cotton Growing Corporation, London.

Manning, H. L. (1949). Planting date and cotton production in the Buganda Province of Uganda. *Emp. J. exp. Agric., 17*, No. 68, 245.

Peat, J. E. (1953). Fertility responses—Ukiriguru. Crop responses to fertilizers and manures in East Africa. *E. Afr. agric. J., 19*, 35.

REVIEWS

GRAZING CONTROL: LAWS AND REGULATIONS IN VARIOUS COUNTRIES FOR THE CONTROL OF GRAZING TO PREVENT INJURY TO GRASSLANDS, compiled by A. G. G. Hill, published by Commonwealth Agricultural Bureaux, Farnham Royal, England, 1959, 27 pages. Price 7*s*. 6*d*.

As population pressure increases so does the need for controls. Free ranging domestic animals can no longer be tolerated where they cause temporary or permanent damage to the ever more scarce reserves of pasture or rangeland. So grazing control develops. This timely survey of existing practice in many countries of the world will help those who must frame legislation on the subject.

WEST AFRICAN COTTON RESEARCH CONFERENCE held at the Regional Research Station, Ministry of Agriculture, Samaru, Northern Nigeria, 18th to 23rd November, 1957, 209 pages. Price 15*s*.

While most of the value of the Conference was no doubt derived by the delegates actually present, those who were not can obtain much by proxy. The main advantage of this publication lies in the printing of the 33 papers presented at the various sessions. They cover a wide range of subjects and workers with other crops will find something in them of interest. They range from Agronomy, through Genetics, Entomology, Plant Pathology and Plant Environment to Legislation, Grading and Marketing.

STORAGE OF MAIZE IN A PREFABRICATED ALUMINIUM SILO IN TROPICAL CONDITIONS

By J. C. Davies, Entomology Section, Department of Agriculture, Uganda

(*Received for publication on 3rd September, 1959*)

Small aluminium silos of 20 to 100 tons capacity are commonly used in temperate countries for storage of conditioned grain, but their use in tropical countries has been limited. As part of a programme to test silos of various types of construction and materials a 20-ton prefabricated aluminium silo was erected at Kawanda in June, 1957. This silo was erected on a rectangular brick and hardcore plinth surfaced with cement and incorporating a water vapour proof layer of roofing felt approximately 6 in. from the surface. A thick layer of "Mastic" was placed under the base ring of the silo with a special gun prior to tightening down the foundation bolts. The silo was erected completely by five men in less than two days.

On 31st July, 1957, the silo was half filled with ten and a half tons of conditioned K8 maize (obtained from Namulonge Cotton Research Station), it being impossible to obtain sufficient maize to fill the silo. The maize was untreated with insecticides, but no live insects were visible when the maize was placed in the silo. The maize was then allowed to settle for a fortnight before the first samples were taken.

Sampling

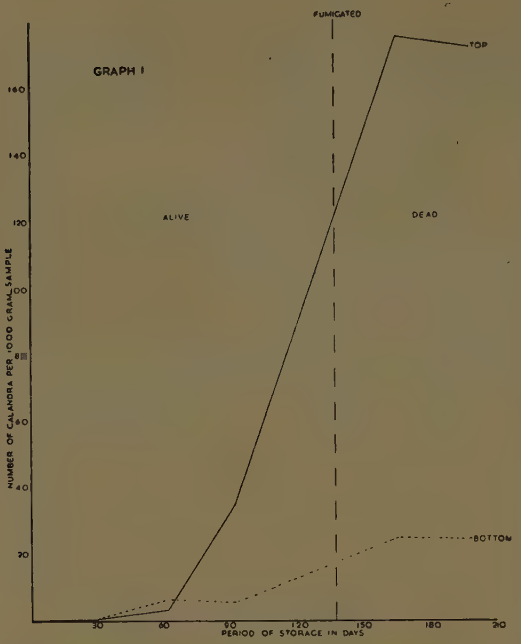
A standard sampling technique was adopted for the duration of the experiment. Samples were taken at two levels, top and bottom, the latter obtained by using a 2 in. diameter grain sampling spear fitted to gas piping. Owing to the length of the spear head the samples from the bottom were actually taken about 6 in. from the floor. Around the circumference 28 probes were made with the spear; at the centre 14 probes were made. The circumferential probes were then bulked into two large samples of 14 probes each and the centre probes were bulked into two large samples of seven probes each. This gave four large samples. A similar number of large samples were obtained from the top. From each of these eight large samples three lots of 1,000 grains were counted out and examined for insect damage, mould growth, germination, etc. Weights of the whole large samples, of the 1,000-grain samples, of the damaged grains and complete grains were taken.

Bulked samples from the top and the bottom of the silo were held in sealed jars for moisture content determination. Sub-samples were ground in an electric mill fitted with a 1-mm. sieve and four replicates of 5 grams of the maizemeal were heated in aluminium slip lid tins; heating was carried out in an electric oven running at 130° C. for one hour. After heating, samples were cooled in a desiccator containing calcium chloride. All weighings were carried out on an electric balance.

Results of Monthly Samplings

The initial samples taken from the top of the silo gave an average percentage insect-bored of 2.1 and from the bottom 3.5. Individual 1,000-grain samples did not vary much from these average figures. Over the first 90 days a slight rise in the number of bored grains was apparent in both top and bottom samples. Thereafter there was a great increase in the percentage of bored grains in the top samples which can be correlated with the spectacular rise in the number of *Calandra oryzae* L. occurring in the samples. The same feature was apparent in the bottom samples but numbers of both bored grains and *C. oryzae* were considerably less. (*See* Figures 1 and 2.)

After 154 days storage, when the percentage of bored grains on the surface was about 38 per cent, the silo was fumigated with a commercial grain fumigant containing ethylene dichloride and carbon tetrachloride in a 3.1 ratio respectively, at a dosage of 6 pints to 1 ton. Subsequently the number of live adult *C. oryzae* in the top and the bottom samples dropped to nil. After fumigation many dead moths mainly *Sitotroga cerealella* Ol. were found in the surface samples, having fallen from walls, etc., where they normally rested. A slight rise in the amount of boring in the surface grain was apparent after fumigation due to slight moth infestation, some of which survived as eggs or larvae. However, even after 225 days storage the percentage of bored grain was only 40 in the top samples and just under 12 in the bottom, so that little damage occurred after fumigation.



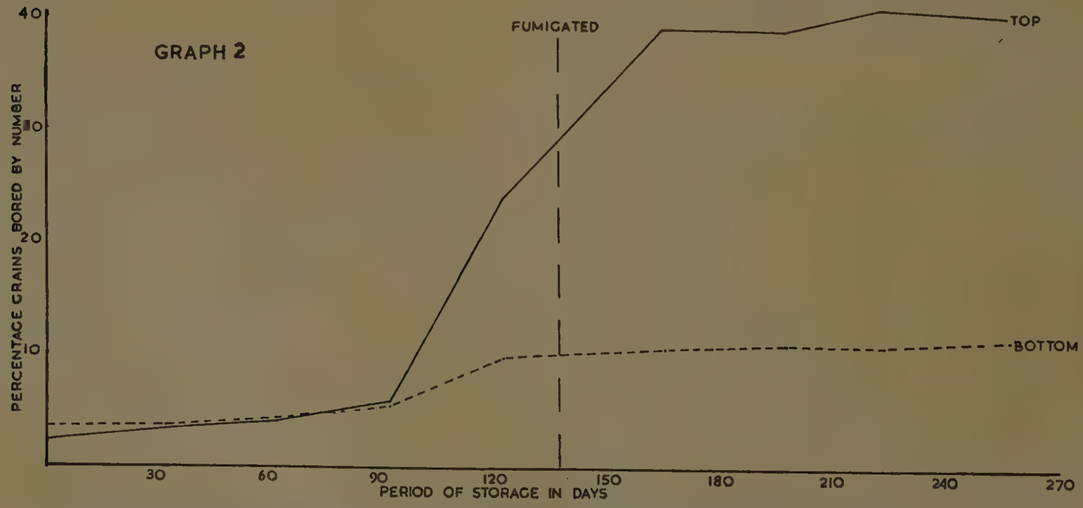
Number of Calandra sieved from monthly top and bottom samples of maize stored in an aluminium silo

On emptying the silo 18 samples of approximately 2,000 grams each were taken at regular intervals. From each sample a 1,000-grain subsample was taken and examined for insect boring, mould, germination, etc. The average percentage of damaged grains calculated from these figures was 17.1. Using the weights of damaged grains and the weights of whole grains an average weight per damaged grain and an average weight per whole grain was calculated. From these figures it was found that the weight loss due to insect infestation was 2.6 per cent.

Incubation of Samples

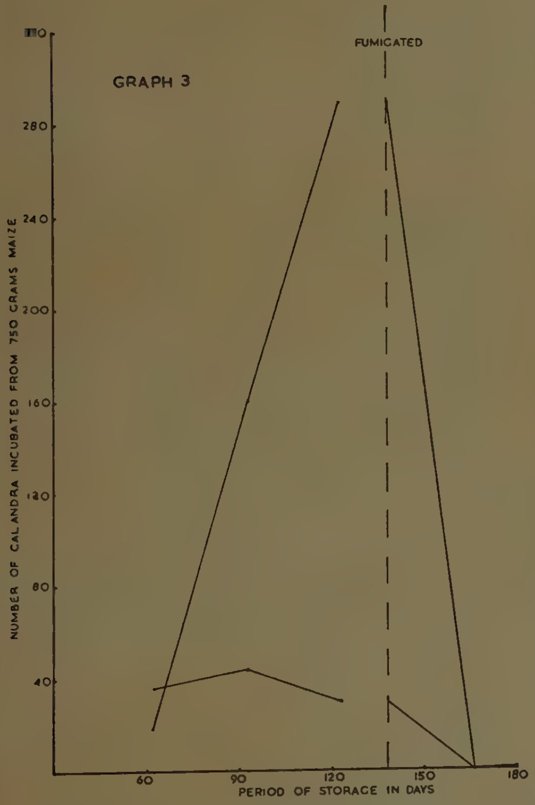
Sieved samples were incubated monthly after the first 60 days of storage at a temperature of 30° C. and a relative humidity of 80 per cent +. The samples, each of 750 grams, were taken from the top and bottom of the silo and were placed in large insect-rearing bottles fitted with rubber bungs and gauze inserts. After one month of incubation the samples were sieved and the numbers of live and dead insects counted. The results for the predominant pest recorded, *C. oryzae*, are plotted in Figure 3, which demonstrates the close correlation between number of *C. oryzae* sieved out and grain damage. The apparent falling off in the number of *C. oryzae* bred from the bottom samples may be due to heating of the lower area of the silo, caused by microfloral activity, which induced or forced the adult *Calandra* to migrate away from the bottom for oviposition. This activity was a direct result of some leakage around the base of the silo. (*See* later.)

Counts were attempted for the most important moth pest, *Sitotroga cerealella* Ol. over the same period, but this was difficult with the very actively flying moths, especially when



Percentage insect damaged grains in monthly top and bottom samples of maize stored in an aluminium grain silo

numbers in excess of 100 were present. An increase in numbers of moth in the top samples per 1,000 grams from 0 at 60 days to over 100 at 120 days was recorded. Very few *S. cerealella* were bred out from bottom samples. It is interesting to note that *S. cerealella* was relatively uncommon in crib experiments carried out at Kawanda. Other insects bred from incubated samples were *Tribolium castaneum* Hbst., *Typhea stercorea* L., *Carpophilus dimidiatus* F., and the moth *Ephestia cautella* Hub. None of these were bred from post-fumigation samples though *T. castaneum* and *E. cautella* were common in the 120-day sample (i.e. the sample taken immediately prior to fumigation).



Number of Calandra incubated from sieved monthly pre- and post-fumigation grain samples

Moisture Content over the Experimental Period

Moisture content throughout the experiment was estimated using the method detailed above. Samples taken for moisture content were immediately sealed in screw-cap bottles with "sellotape" and surface inch of maize in each bottle was discarded before grinding. The maize had an average moisture content of 14.19 per cent at the start of the experiment, and throughout the storage period very little change occurred, fluctuations never exceeding .45 per cent for the top samples and .25 per cent for the bottom samples. After emptying the silo it was possible to obtain samples from the layer of grain close to the floor. These figures were over 1 per cent above the initial moisture content of the grain. The increase had led in the very lowest layer to mould formation and spoilage.

Observations on the Emptying of the Silo

A little rain had entered the silo in the region of the outlet spout through a hole provided for fixing a lock. In all, about a pound of maize was spoilt, but this was sufficient to prevent the grain flowing out. When this was removed the grain flowed freely. When the silo was more or less empty it was apparent that the lower 1 in. to 2 in. had been damaged by mould growth. In all, 1,017 lb. were damaged of which 649 lb. were suitable for cattlefeed.

The mould growth was caused by leakage of water under the base ring of the silo, although some leakage may have been due to capillary movement through the cement. Standing water was observed on the rectangular plinth in times of heavy rain, but no rain entered through the walls or roof.

Where several silos are erected on a common plinth it may therefore be necessary either to slightly raise the area on which the silo stands (this was done for a second silo but grain was unfortunately not available to conduct an experiment) or else to cover this area with a high melting point bitumen compound. Considerable trouble could occur when attempting to clean and/or disinfest the silo if the bitumen did not possess a high melting point. A further measure would be to cover the entire plinth area with bitumen. Runnel grooves do not in themselves appear to be a sufficient safeguard in time of heavy rain.

While the silo was being emptied, samples were taken as described above. When these samples were sieved very few live insects were rcorded, in fact only one live *C. oryzae* and four live *T. castaneum* from over 36,000 grams. Some live *S. cerealella* moths were seen on the silo walls.

DISCUSSION

The results show that use of small silos in Uganda conditions would be a useful method of storage, especially for large estates where maize is stored for nine months or so to provide food for labour; such estates often have woefully inadequate means of storage and losses caused by infestation are high. Once adopted as regular practice a routine treatment with fumigant would be necessary as field infestation of Uganda maize by *C. oryzae* does occur. In the course of normal storage the infestation would not be allowed to develop as it did in the experiment and damage would be considerably less. Even though infestation was allowed to reach a high level in the experiment the sample was readily accepted by the trade and at time of sale there was very little live insect activity in the maize.

A factor which must be borne in mind is that the maize used was conditioned to around 14 per cent and any attempt to store maize with a moisture content much in excess of this figure would, in tropical conditions, result in disaster. In Uganda except in the drier areas of the Protectorate, maize is seldom under 17 per cent moisture content when brought into store, and an all-round improvement of drying on farms may be essential before this method of storage can become widespread.

SUMMARY

1. An experiment using an aluminium grain silo for maize storage is described.
2. Figures illustrating the rise in insect infestation in top and bottom samples from the silo are given.
3. Control of a heavy infestation of *Calandra oryzae* with carbon tetrachloride and ethylene dichloride was achieved.

ACKNOWLEDGMENTS

My thanks are due to Mr. J. Bowden, Senior Entomologist, Uganda, Dr. D. M. Robinson, Namulonge Cotton Research Station and Mr. T. R. Odhiambo for reading and criticizing the draft of this paper. The assistance of Messrs. Kasaija and Nyiira in making the counts is gratefully acknowledged. Thanks are also due to the Director of E.C.G.C. Cotton Research Station, Namulonge, for the loan of the maize used in this experiment. Permission to publish this paper has been obtained from the Director of Agriculture, Uganda.

REFERENCES

Anon. Sampling Grain from Bins. *Nat. inst. agric. Engng.* Tech. memo. No. 35.

Lucas, C. E. & Glover, R. S. On making measurements in Silo-stored Grain. *Ann. App. Biol. 33.* 1946.

Warner, M. G. R. The Sampling of Grain. *The Agric. Merchant,* May, June, 1955.

Warner, M. G. R., Berry, P. E., & Williamson, W. F. Experimental Outdoor Grain Storage Silos. *Nat. inst. agric. Engng.* Tech. memo. 98.

Warner, M. G. R. Grain Storage in Outdoor Silos, 1952-55. *Nat. inst. agric. Engng.* Rept. No. 47.

REVIEW

SOIL AND LAND-USE SURVEYS, by the Regional Research Centre of the British Caribbean. Obtainable from the Imperial College of Tropical Agriculture, Trinidad, B.W.I. No. 6—British Guiana.

(1) The Rupununi Savannas. (Contd.)

(2) The Intermediate Savannas.

(3) General Remarks, by J. Stark, G. K. Rutherford, J. S. Spector and T. A. Jones, 24 pages and map. Price 15*s*.

This report continues the survey of British Guiana which began with Nos. 2 and 5 in this series. It includes summaries of the climate, geology, ecology and land-use, with descriptions of the soil genesis and profile characteristics, soil classification, physical properties and the minor and trace element status of the soils of the Intermediate Savannas.

SELENOTHRIPS RUBROCINCTUS (GIARD) AND THE FLORAL BIOLOGY OF CASHEW IN TANGANYIKA

By M. Bigger, Department of Agriculture, Nachingwea, Tanganyika Territory

(*Received for publication on 11th September, 1959*)

Attacks of *Selenothrips rubrocinctus* on cashew tend to be somewhat localized, confined usually to a small group of trees, but may be spread over an area of an acre or two in extent. It is by no means as serious a pest of cashew as, for instance, the Mirids *Helopeltis bergrothi* and *H. anacardii* but in its restricted areas of infestation the loss of crop is considerable.

During 1958 Helopeltis attack on cashew in the Southern Province did not occur and this seemed a favourable opportunity to assess the damage caused by the thrips while it was not masked by the dieback attributable to Helopeltis. At the same time useful data were obtained on flowering, and nut yield.

S. rubrocinctus is a leaf-feeding thrips, both the nymphs and adults being found on the underside of the leaf where their feeding results in a "rosseting" of the upper surface. They are not confined to the leaves however but may be found on the young shoots, on the branches of the flower panicles and on the flowers themselves. The older leaves which have been attacked generally fall giving the tree a thin appearance with long bare shoots surmounted by tufts of young leaves.

The attack is essentially a dry season phenomenon commencing when the rains end in May and continuing until they begin again in December. It is thus just about at its maximum from September to November during the harvest period.

BIOLOGY OF CASHEW

Cashew (*Anacardium occidentale*) belongs to the family Anacardiaceae. It is an evergreen tree reaching a height of 30-40 ft. and is usually rather spreading in habit. Branching begins close to the ground and unless the lower branches are removed they tend to trail. Most native-grown trees are shaped to some extent having these lower branches removed; this facilitates harvesting as the nuts are allowed to fall and are collected from the ground.

A study of young trees shows that the maximum growth takes place during the rains from January to April but there is evidence of two lesser periods of increased growth in August and November. The November peak corresponds to a marked flush of young leaves which follows fruiting on older trees (Fig. 1). Most trees bear some flowers and fruit in their second year but it is not until the third season that the yield is worth collecting. A few trees may flower when less than one year old.

The inflorescence is a panicle and is usually borne terminally although lateral inflorescences may also be seen. For this reason the majority of the flowers are to be found on the periphery of the tree, on new wood. Both male and hermaphrodite flowers are produced on the same inflorescence, the flowers being small, whitish-green or red in colour and scented.

According to Rao and Hassan (1957), pollination is by wind. They report that in India no insects other than ants are to be found on the trees. In Tanganyika there is no

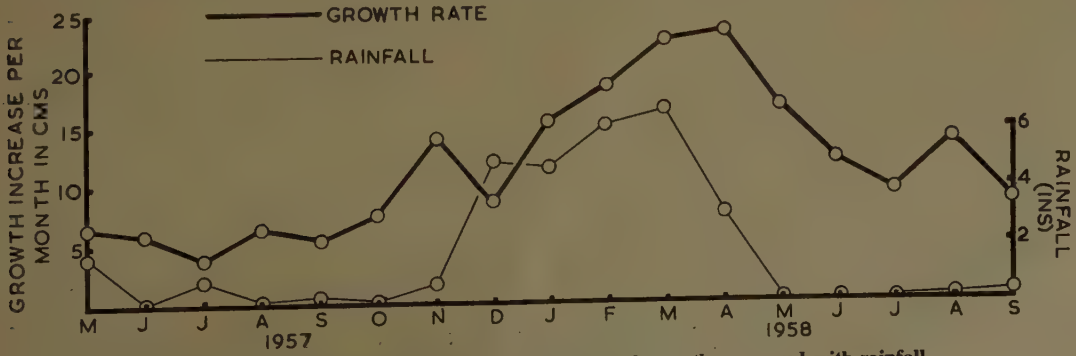


Fig. 1.—Increase in size of young cashew trees each month compared with rainfall

lack of pollinating insects, attracted no doubt by the strong scent of the flowers, and at flowering time the fly population of the cashew plantations increases markedly. These insects must play a considerable part in pollination although the high proportion of male to perfect flowers suggests that the tree may be basically wind pollinated.

The nut is borne on a fleshy apple which represents the swollen peduncle. It is about three inches long and either red or yellow in colour when ripe. The nut itself has a tough leathery grey testa which contains a valuable oil used for a diversity of industrial purposes, including the manufacture of brake linings and plastics.

Propagation is by seed although air layering shows promise as a means of propagating clonal material. It has been shown (Turner, 1956) that a higher percentage of germination is obtained by selecting nuts with a high specific gravity, those with a specific gravity greater than 0.075 giving 90 per cent germination.

The Effect of Thrips on Flowering and Nut Yield

Flowering.—The trees chosen for observation were part of a 150-acre field on one of the farms of the Tanganyika Agricultural Corporation at Nachingwea. The practice of the Corporation is to plant on a square pattern at intervals of 20 ft. x 20 ft. and to thin at a later date. These trees, which were approaching four years of age when recording began, had not been thinned, but the canopy was not yet touching. There were, therefore, approximately 100 trees to the acre.

A block of 100 trees suffering from thrip attack was marked out together with a similar block free from thrips, nearby. The trees were not all infested to the same extent and a number escaped attack altogether. The trees could be divided roughly into five grades according to the incidence of attack, and the distribution of infested trees is shown in Fig. 2.

It will be seen that there appear to be two main points of origin from which the thrips have spread and that the area covered in each case is not in fact very large. The grading was done on a purely arbitrary basis and has no numerical value.

Counts were made at fortnightly intervals of the inflorescences on each of the 200 trees. No inflorescence was counted until it bore open flowers and counting continued until the last nut, or if it bore no nuts the last flower, fell. As the panicles lasted up to 20 weeks it will be evident that they were included in the counts a number of times and the recordings show only the total number of inflorescences present on the tree at any time and not the number produced each fortnight.

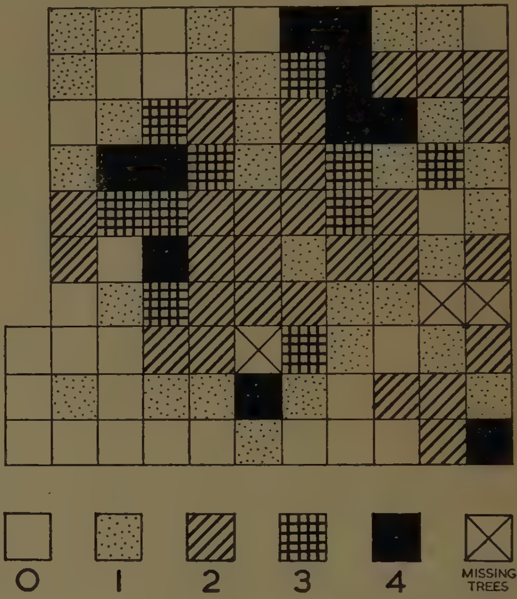


Fig. 2.—Severity of attack by Selenothrips on a block of 100 cashew trees

To facilitate counting long bamboo poles were laid against the tree to cut the surface into segments. On trees with many flowers up to eight poles were used. In this way it was possible to make a fairly accurate estimate of the number of panicles present, and with the large number of inflorescences involved it was a very suitable method. The largest number of inflorescences recorded on a tree at its maximum bearing was 767.

Recording began on 12th June when flowering had already commenced but while the number of flowers present was still low. There was an increase in flower production up to the middle of September when the maximum was reached and thereafter numbers fell until the end of the year.

Considerable variation was found in the maximum number of inflorescences borne per tree and in the date at which the trees reached their peak. The latter varied over a period of 14 weeks but for both the attacked and unattacked trees the mean occurred about the middle of September (Table I and Fig. 3).

The maximum number of inflorescences borne at any one time varied from 0 to 767 with means of 266 for the attacked trees and of 207 for the unattacked. (Table II.)

TABLE I.—NUMBER OF TREES REACHING MAXIMUM FLOWERING EACH FORTNIGHT

Date	Thrip attacked	Thrip free
6–8–58	7	0
21–8–58	5	5
5–9–58	18	29
18–9–58	49	25
3–10–58	8	28
16–10–58 ..	7	10
30–10–58 ..	1	2
13–11–58 ..	1	1

TABLE II.—INCIDENCE OF PEAK NUMBERS OF INFLORESCENCES PER TREE

No. of Inflorescences	Thrip attacked trees	Thrip free trees
0–99	19	28
100–199	19	29
200–299	22	18
300–399	14	11
400–499	13	10
500–599	5	3
600–699	3	1
700–799	1	0
Mean	266	207

During the entire flowering period the infested trees bore a greater number of inflorescences than the control, at their peak period having 33 per cent more flowers (Fig. 3). It is thought that this must be a reaction on the part of the tree to the defoliation caused by the thrips as the average of those trees of the infested block not attacked by thrips was very close to that for the control block. (212 and 207 respectively.)

Although the main flowering period extends from June to November a few inflorescences may be found at any time of the year but during the rains any nuts produced generally turn black and rot on the tree. By the third week in January a slight increase in flowering was apparent but unfortunately the trees underwent a severe pruning at this time which rendered further recording out of the question. However, it is safe to say that any out of season flowering is of minor significance compared with that taking place during the main period.

Nut Yields.—Nuts were collected from individual trees at weekly intervals and their number and weights recorded. At the end of the season the total yield from each tree was graded for specific gravity. This has an important bearing on the germination of the nuts and will be discussed more fully later.

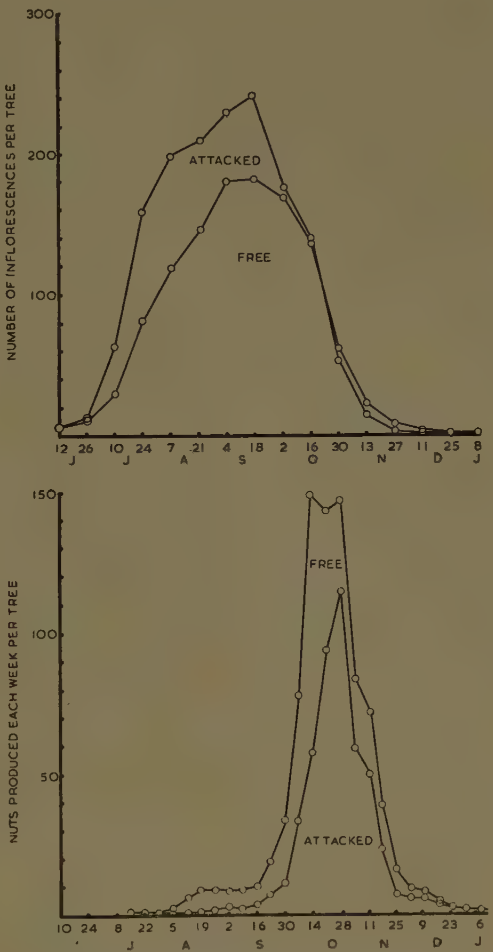


Fig. 3.—Effect of Selenothrips on flowering and yield of three-year-old cashew trees

The local practice was followed of collecting fallen nuts from below the trees. They are not picked from the trees in Tanganyika as they are in other parts of the world but there seems to be little advantage in doing so, under local conditions, as harvesting takes place entirely during the dry season when there is little fear of rain.

Recording began on 15th July and the yields from the unattacked trees rose until the third week in August when they reached a low but steady level which was maintained until the middle of September. At this point there was a rapid increase until a peak was reached during the second week of October. Thereafter there was an equally steep fall until the beginning of December after which yields tailed off gradually. The entire harvest period occupied about 22 weeks but over 90 per cent of the nuts were collected from the trees during the 11 weeks from 16th September to 2nd December. The thrip infested trees followed a similar pattern except that the early increase was not reproduced and numbers of nuts were far lower throughout the season. The yield from the block of 100 infested trees was only 59 per cent of that obtained from the 100 trees free from thrips. (Table III and Fig. 3.)

TABLE III.—TOTAL NUT YIELD FOR EACH BLOCK OF 100 TREES (I.E. PER ACRE)

	No. of Nuts	Wt. gm.	Wt. lb.
Free ..	85,602	289,721	637
Attacked ..	47,485	171,806	378
Difference..	38,117	117,815	259

It is interesting to note that although the thrip infested trees produced a greater number of inflorescences their nut yield was much lower. This is because the panicles bore a smaller number of flowers and the percentage of nuts formed was very much lower than on the unattacked trees.

Individual trees showed great variation in yield, the lowest recorded number in the case of the unattacked trees being 30 nuts and the highest 2,544 and of the infested trees 0 and 1,912. (Table IV.)

TABLE IV.—VARIATION IN YIELDS OF TREES

No. of Nuts per tree	Attacked trees	Unattacked trees
0–250 ..	40	15
251– 500 ..	25	19
501– 750 ..	11	18
751–1,000 ..	12	14
1,001–1,250 ..	8	13
1,251–1,500 ..	2	7
1,501–1,750 ...	1	5
1,751–2,000 ..	1	4
2,001–2,250 ..	0	1
2,251–2,500 ..	0	3
2,501–2,750 ..	0	1
Means	475	856

Specific Gravity Determinations.—By grading the nuts in solutions of different specific gravity it was found that the quality of the nuts from attacked trees was also below that of nuts from trees free from attack. Turner (1956) has shown that by planting nuts of high specific gravity much better germination results. He used five specific gravity grades, less than 1.000, 1.000-1.025, 1.025-1.050, 1.050-1.075, and greater than 1.075 and obtained germination percentages ranging from 30 per cent for the lowest to 90 per cent for the highest. The rate of germination of high specific gravity nuts was also greater, as was the percentage of sound kernels. It will be seen from Table V that the highest percentage of nuts from unattacked trees falls in the highest grade whereas one third of the nuts from trees attacked by thrips are to be found in the lowest grade. On the other hand the average weight of each nut from the attacked trees (3.62 gm.) is greater than those free from attack (3.38 gm.) from which it may be deduced that the nuts from the infested trees are larger in size though not in content. This bears out Turner's observation that the largest nuts of a sample are generally of a low specific gravity.

TABLE V.—EFFECT OF SELENOTHRIPS ATTACK ON DENSITY OF CASHEW NUTS

Specific gravity Grades of Nuts	Percentage of Crop in each Grade	
	Trees attacked by *Selenothrips*	Trees free from *Selenothrips*
Less than 1·000	33·6	19·6
1·000–1·025 ..	13·2	9·5
1·025–1·050 ..	26·7	17·7
1·050–1·075 ..	18·1	25·6
Greater than 1·075	8·4	27·5

Analysis of the weight of the average nut from week to week (Fig. 4) shows that after a period of great variation due to the small numbers recorded there is a steady increase in weight until the 23rd September, at which date the main harvest begins, and thereafter a drop until the 25th November which corresponds to the end of this period. A further variable phase follows in which the general trend is towards heavier nuts. If the average specific gravity is constant throughout the season, and recording up to the middle of September suggests that it may be, then the curves give an indication of the relative sizes of the nuts, an upward trend showing an increase in size and downward one a decrease. There is thus an increase in the size of the nuts during the earlier part of the season until the main nut fall begins, after which they become progressively smaller. Out of season nuts tend to be larger than those falling during the main harvest period. This agrees well with observations in the field as the nuts do in fact decrease in size as the season progresses. (Fig. 4.)

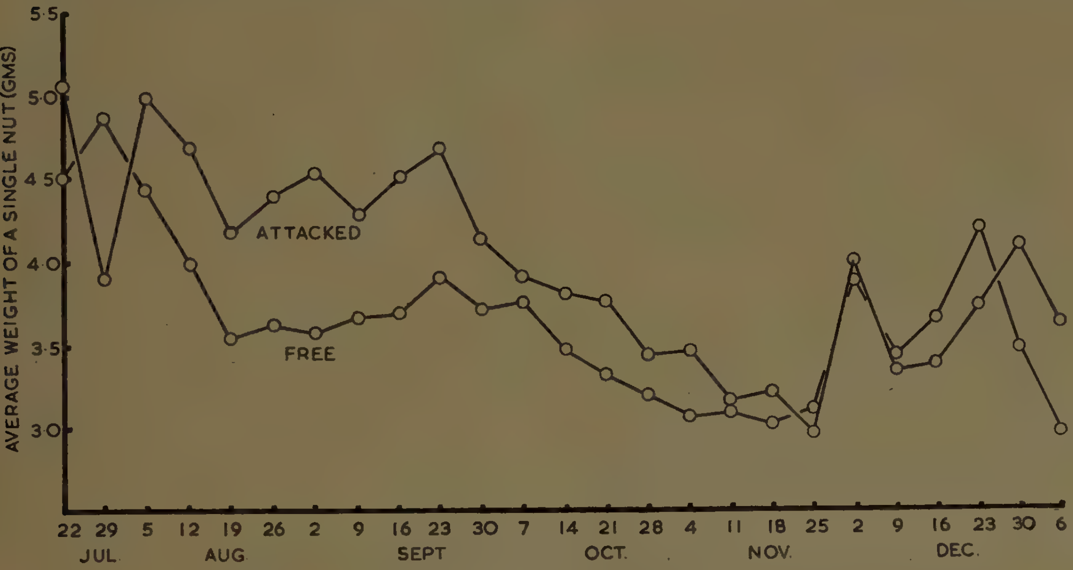


Fig. 4—Changes in the weight of cashew nuts and the effect of attack by Selenothrips

Composition of the Inflorescence.—Observations were also made on the composition of the panicles to assess the damage done by the thrips to the flowers and also to find the percentage of nuts reaching maturity and the ratio of male to perfect flowers.

One inflorescence from each of the 100 trees on each block was tagged and counts made each week of buds, male and hermaphrodite flowers, and nuts. The nuts were further classified into young and mature. They are at first reddish-green in colour but before falling harden and turn grey. At the same time the apple turns from green to red or yellow. At this stage they are considered mature.

As the first buds had already appeared when recordings began there was some variation in the age of the panicles. The appearance of the first flower was therefore used as a datum in each case and the time for development of the inflorescences phased to this.

The first buds produce the panicle branches and it is not for some weeks that flower buds are produced. The time taken from the first appearance of the inflorescence to the opening of the first flowers is about 5-6 weeks. For the first three weeks after the commencement of flowering the hermaphrodite flowers are most numerous but later the male flowers predominate.

The hermaphrodite flowers reach their maximum by the third week and disappear finally by the sixth week, the male flowers are at their maximum by the sixth week and continue until the tenth. These times are averages and individual panicles vary considerably. Thrip attack does not seem to affect the trees in respect of flowering period except that the perfect flowers are borne over a longer period and the male flowers over a slightly shorter period.

The nuts make their appearance in the first week after flowering, mature in seven weeks and fall by the eighth week. The percentage of perfect flowers producing nuts which reach maturity is 10.2 per cent on uninfested trees and 3.8 per cent on those attacked by thrips. These heavy losses are the sum of a number of adverse factors two of the more obvious being failure of pollination and attack by insects. Among the latter, one of the worst offenders is the Coreid *Pseudotheraptus* which blackens and kills the younger nuts and produces pitted black lesions on older nuts. Another Coreid *Tupalus fasciatus* induces similar damage but is not generally seen on the tree during the harvest period, confining its attacks to the wet season. There is also a high mortality of very young nuts presumed to be physiological in nature where there is no evidence of insect damage.

The total number of perfect flowers produced per inflorescence did not vary greatly between the two blocks, the average number for the thrip attacked trees being 63 and for the others 67. On the other hand the undamaged trees produced a great many more male flowers than the damaged, the averages being 419 and 251 per inflorescence respectively. The ratio of male to hermaphrodite flowers is thus greater for the unattacked trees (6:1) than for the attacked (4:1) which might bring about a reduction of the percentage of pollination.

Of the 100 tagged inflorescences in each block 29 from the infested trees and seven from the uninfested failed to produce mature fruit.

DISCUSSION

In spite of the drastic local reduction in yield for which it can be responsible, *Selenothrips* cannot be considered a pest of major importance on cashew due to its limited range. It seems to be incapable of building up to a sufficient extent to move far from its point of origin during its short season. The infestation under review occupied an area of little over an acre in extent in a year when the rains ended much earlier than is usual. It seems probable that in a year of normal rainfall the infestation would not have spread to nearly the same extent.

In a large plantation it would not be economical to apply a control measure to the entire area for the sake of a few infested trees nor practical to seek out the trees attacked by thrips and treat them individually, but in native cashew where the entire holding may not exceed ten or a dozen trees control measures might well be applied. An increase of 200 lb. per acre where the infested acre is part of a 100-acre plantation would not be noticed but where it represents the entire holding it becomes an attractive proposition.

So far no attempt has been made to control thrips as the extent to which they reduce yields was not appreciated but it is hoped that measures taken against *Helopeltis* will keep the thrips population in check also.

The data on yields provide a useful yardstick for further work on cashew pests as it was not previously known what a tree of this age, or for that matter any other age would produce under local conditions. Local cashew appears to be more efficient in flowering than cashew studied at Mangalore by Rao and Hassan (1957). These authors record that only 22 out of 84 tagged inflorescences bore fruit, 74 per cent failing to do so, while only 29 per cent of inflorescences on the unattacked local trees and 7 per cent on the attacked did not produce mature nuts. At Mangalore the total number of flowers produced per inflorescence was 329 while the local trees produced 314 and 486 per inflorescence on the attacked and unattacked respectively. The percentage of mature nuts produced to number of perfect flowers was lower, 3 per cent as against 3.8 per cent and 10.2 per cent at Nachingwea. The percentage of perfect flowers was 4 per cent as compared with 20 per cent and 14 per cent for the attacked and clean trees at Nachingwea.

The authors were not concerned with yields so it is not possible to compare the trees in this respect nor do they give any clear indication of age, so it is possible that the differences in the characteristics of the inflorescence may be due to a difference in age.

SUMMARY

Observations were made of the effect of *Selonthrips rubrocinctus* on three-year old cashew trees.

Inflorescence counts showed that the attacked trees were producing more flowers than the unattacked but it was later found that yields were lower. The trees flowered from July-December reaching a maximum in mid-September. Ninety per cent of the yield was produced between the middle of September and the beginning of December. Thrip attack brought a loss of 259 lb. per acre of nuts, the infested trees producing 378 lb. per acre and the uninfested 637 lb. per acre.

It was found that time of development of the inflorescence was not seriously altered by thrips attack. On the other hand the number of male flowers was drastically reduced although the perfect flowers remained at more or less the same level. This seems to have had an effect on pollination as the set of nuts was reduced from 10.2 per cent of the perfect flowers to 3.8 per cent. The percentage of panicles producing mature nuts was also reduced from 93 per cent to 71 per cent.

Although thrips reduce yields in this way they cannot be considered serious pests because of the extremely local nature of their attacks, rarely being found in areas of more than a few trees in extent.

REFERENCES

Rao, V. N. M., and Hassan, M. V. (1957). Preliminary Studies on the Floral Biology of Cashew (*Anacardium occidentale*). *Ind. J. agric. Sci. 27*: 277.

Turner, D. (1956). Some Observations on the Germination and Grading of Cashew Nuts. *E. Afr. agric. J. 22*: 35.

CONTROL OF INFECTIOUS DISEASES OF ANIMALS: II

By Sir Thomas Dalling, Consultant of the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

There are a few more important diseases which occur in both animals and human beings which are discussed in this article.

RABIES

Rabies is widespread throughout many parts of the world: all types of animals are susceptible and may develop the disease when exposed to the causal virus. While, in some countries, it is seldom that rabies is found in any animals except dogs and cats, the susceptibility of domestic animals in general must not be forgotten, nor must we forget that wild animals, especially carnivores, may also develop the disease and may be spreaders of the infection. Again, attention is drawn to the part played in some parts of the world by blood-sucking bats in infecting domestic animals: it is also recorded that insectivorous and fruit-eating bats may, sometimes, also transmit the virus. Except in areas where blood-sucking bats are present or where wild carnivores have become infected, the infection is most commonly transmitted to animals and human beings by infected dogs and cats, whose saliva contains the causal virus. The recognition of the part played by infected dogs and cats in conveying the disease forms the basis of methods of control applied in many parts of the world.

Lengthy Period of Quarantine Essential

In countries normally free from the disease its introduction is guarded against by imposing strict quarantine measures, especially for all dogs and cats entering the country. Because there may be an interval of many months between the actual infection of an animal and the appearance of symptoms of the disease, a long quarantine period is essential. Criticism is sometimes made of the lengths of the quarantine period imposed by the authorities in some countries. Experience has shown, however, that they are necessary if the introduction of the disease is to be prevented; in spite of all the opposition, the actions of the authorities must be supported in continuing to impose these lengthy quarantines, no matter how drastic they may appear to be.

It may not always be possible to diagnose rabies in an infected animal during life. The symptoms may vary considerably and it may be necessary to continue observation of a suspected animal for some days before definite clinical evidence of the disease is forthcoming. It is important, however, that all human beings bitten by dogs or cats in countries in which rabies is endemic should be placed under medical care, irrespective of whether or not it is proved that the animal in question is actually suffering from rabies. In dealing with rabies, intimate collaboration between veterinary and medical authorities is absolutely essential. The actual diagnosis of rabies is normally made by transmission of the causal virus contained in the central nervous system to small laboratory susceptible animals, e.g. mice or by the finding of typical changes in parts of the brain of infected animals by microscopic examination or by both methods.

New Types of Vaccine

Vaccination of animals is often carried out as a control measure. The treatment of human beings with vaccines following exposure to infection, e.g. bites by infected or suspected dogs and cats, has been practised for many years with excellent results. More recently, since the elaboration of new types of vaccine, especially those prepared from strains of attenuated rabies virus cultivated in the developing chick embryo, vaccination campaigns for the prevention of the disease in animals are being carried out in several countries. There are now available vaccines which have been shown to afford protection for some years. Vaccination of the larger domestic animals is also practised in countries in which bat transmission of the infection is common.

Experience has shown that in campaigns in which vaccination of dogs is an essential part, it is necessary for success that the whole of the dog population of the area is dealt with: ownerless or stray dogs have to be destroyed and all other dogs registered and vaccinated. Unfortunately, the success hoped for has not been attained in all countries. The continued presence of infected wild animals, especially in neighbouring countries, constitutes a difficulty. It can readily be appreciated that international action may be necessary finally to eradicate rabies from a region.

LEPTOSPIRAL INFECTIONS IN ANIMALS AND HUMANS

A group of organisms, designated leptospira, is responsible for the disease *leptospirosis* in domestic animals and human beings. Within recent years, our knowledge of these diseases in animals has advanced considerably although they have been recognized, for a long time, as causes of human disease, especially occurring where conditions of work expose the personnel to the infections.

Leptospiral infections may be found in all species of domestic animals and in all countries of the world. the incidence and the severity of the infections, both of which vary greatly, depending upon epidemiological and ecological conditions. Natural infections occur in cattle, sheep, goats, pigs, horses, donkeys, dogs and cats. Although there are many types of leptospira, it is seldom that more than one type is found in a species of animal; a different type may, however, be found in the same type of animal in different parts of the world. It has also been observed that the same type of leptospira may be present in different species of animals.

Various Symptoms of the Disease

Leptospirae cause disease in which the symptoms and severity vary from an extremely mild condition to very severe attacks, resulting in deaths. Sometimes, it is necessary to employ laboratory tests on blood to demonstrate that infection is actually present. Milk symptoms are often characteristic of the disease in pigs in which abortion may occur; in horses, the infection may be localized to the eyes or may affect the central nervous system; in cattle, the severity may vary from the occurrence of mild to severe symptoms with lowered milk yields, abortion, jaundice, high fever and even mastitis; in dogs, the disease, especially following infection with some types, is often serious, with the occurrence of gastro-enteritis, jaundice and kidney troubles but, with other types, the disease is much milder in character.

Leptospirae are spread either by vectors, usually wild rodents, and by domestic animals which, although showing no symptoms of the disease, are carriers of the infective agents. The organisms, which are highly sensitive to heat and other adverse climatic conditions, can remain active in parts of the kidney and in the bladder for long periods and are excreted in varying numbers in the urine. Contamination of foodstuffs and water by infected urine is the usual source of the infection for domestic animals but actual contact with infected animals may also give rise to the disease.

There seems little doubt that methods of animal husbandry have an influence on the occurrence and spread of infection by leptospirae; the more intensively animals are kept, the more likelihood is there of spread within groups.

Need for More Research Work

Control measures must vary according to circumstances and conditions. Wherever possible, infected animals should be diagnosed by the application of laboratory tests on their blood and a strict isolation of infected from non-infected animals should be practised. Measures should be adopted to ensure the exclusion of infection by wild rodents. Vaccines have proved useful in human medicine. There is still need for research work, especially with attenuated leptospirae, for the preparation of vaccines for wide use in animals so that immunity for at least one year can be provided.

SALMONELLAE

Members of the group of micro-organisms, termed *salmonellae,* are causes of diseases in animals and poultry. Some also infect human beings, the infecting bacteria being often found in animals and products of animal origin. There is also evidence that some of the infections in animals may be derived from infected human beings. The group contains many members, but all of them are not disease producers: some are more virulent than others and some are responsible for disease in one species of animal more than in others. Some members of the group, at one time unknown in a country, have been introduced in imported products of animal origin, especially eggs.

In cattle, the most severe infections occur in calves, usually when about 10-15 days old and cause a gastro-enteritis, often referred to as "white scour". The disease is common in many parts of the world and can spread rapidly in a group of calves, especially if housed together under unsatisfactory hygienic conditions. In pigs, salmonella infections are often found concurrently with swine fever but they may also exist independently. Some of the salmonellae are also responsible for abortions, particularly in sheep and horses.

"Carriers" in the Animal World

As in human beings, "carriers" of the infection exist in the animal world. The cycle of infection in pullorum disease (bacillary white diarrhoea) is well recognized, in which breeding hens, recovered from the disease, may continue to harbour the causal organism and produce infected eggs, with high mortality of either the developing embryo or the young chicks soon after hatching. Cattle, which have been infected, even without much clinical evidence of the disease, may also continue to harbour the causal agents, i.e. they become "carriers", and it is often from such animals that calves become infected. The introduction of such a "carrier" may establish the infection in a herd free from salmonellosis. It is not always easy to detect "carrier" animals. The recovery of salmonellae from the faeces is definite proof but, because excretion of the organisms is irregular, a single examination may give misleading results. Agglutination tests with serum from the blood of infected and "carrier" animals also give valuable information provided the specific salmonella involved is known. A combination of these two methods of diagnosis gives the most satisfactory results, The value of the agglutination test alone in detecting "carriers" of the salmonella causing pullorum disease is, of course, recognized throughout the world.

Salmonellae may be conveyed mechanically from infected to healthy animals: flies, rodents or even wild birds may take part in this transmission. Infection may persist in faeces for long periods and, therefore, in considering control measures, careful and satisfactory disinfection of premises must be regarded as an essential part.

A further possible source of infection is animal foods and fertilizers prepared from inedible meat and offal from slaughterhouses: from contaminated fish and even from concentrates of vegetable origin. The possibility of such substances being infected with salmonellae requires their adequate sterilization during preparation.

Humans May Spread Infection

Attention must be drawn to the part played by human beings in the spread of salmonella infections. Human "carriers" working in abattoirs and engaged in any work necessitating the handling of meat and meat products may infect these substances.

In spite of the claims made for the successful treatment of acutely or even mildly affected animals, as with many other infectious diseases, the best results will always be obtained by the operation of preventive measures.

Before leaving the subject of diseases common to animals and human beings, stress must be laid on the importance of controlling the infections in animals, which play such a large part in their continuing presence in the human population.

MASTITIS

Inflammation of the udder in lactating animals, or *mastitis,* is one of the commonest diseases of cattle throughout the world. As milk production becomes intensified, the greater is the tendency to the occurrence of mastitis. The disease arises from the invasion of the delicate structures of the udder by micro-organisms which cause the development of the inflammatory processes resulting in acute or chronic mastitis. A large number of different micro-organisms is associated with mastitis and in controlling the disease it is highly important to know the types which are present in the udder. Different types of streptococci are common invaders and much work has been done on their classification and on their disease-producing qualities. Staphylococci cause mastitis in an acute form. Other organisms commonly associated with mastitis are *Corynebacterium pyogenes, Bacterium coli, Myobacterium tuberculosis, Clostridium welchii* and yeast-like organisms or fungi, while some workers think that there may also be a virus as an essential cause of some outbreaks.

In considering the control of mastitis we must always keep in mind that there are several predisposing causes which tend to lower the resistance of the udder tissue and open up the way for the introduction of the infecting agent. These include injuries, chilling of the udder through exposure of the animal to sudden changes in temperature, rough handling of the udder, improper or imperfect milking either by hand or by machines; feeding, too, may be related to the occurrence of the disease. Infectious agents are also conveyed from animal to animal by direct or indirect contact: this takes place by milkers' hands, contaminated teat cups, contaminated cloths for cleansing the udder and any other agent making such contacts. The part played by flies, especially in "dry" cows, has also to be considered.

The prevention of mastitis must centre round the avoidance of such contacts. Early recognition of infected animals is essential and for this purpose the use of the strip cup on each animal before milking is valuable. Some types of simple chemical tests can also be made. The recognition of the causal agents, however, can be done only in the laboratory where the necessary equipment and facilities are available. Much can be done in the milking sheds to prevent mastitis and its spread. Good milking hygiene and methods, as well as careful handling of the animals themselves, are essential and have been shown repeatedly to lower the incidence of the disease.

Treatment with Antibiotics

With the introduction of newer types of chemical agents and antibiotics, the treatment of mastitis has undergone marked changes. The use of antibiotics, injected into the udder through the teat canal, is now the universal method of treating and even preventing most types of mastitis. It has to be recognized, however, that all the infecting micro-organisms are not equally responsive to the same antibiotic and that some are quite unresponsive to any of the antibiotics yet produced. It is, therefore, necessary to know which micro-organism is associated with mastitis in order that the agent to be used for treatment may be selected and that disappointment will not follow the treatment used.

GOOD MANAGEMENT REDUCES MORTALITY

Diseases among young animals vary considerably throughout the world: mortality is high in regions where modern hygienic methods are not in every-day practice. Mortality among young animals can be reduced to a very low figure if good methods of management are introduced and precautions are taken to prevent obvious causes of ill-health. There are many causes: some are infectious agents which involve individuals or groups of animals, some are nutritional in origin, some concern hereditary conditions transmitted by the dam or sire or both, some are essentially related to management. Salmonellosis in calves, which may spread rapidly, was discussed in a previous article.

Infection of lambs and young sheep with the anaerobic group of micro-organism are examples of diseases found in different parts of the world, now being well controlled and prevented as the result of much research work. Our knowledge of anaerobic bacteria has been greatly increased by studies of some of the causes of mortality in lambs and young sheep. Most of the bacteria concerned produce toxins in the alimentary tract which, following absorption through the intestine, cause the animals' deaths. *"Lamb dysentery"* is an example of such a disease.

The bacterium responsible is *Clostridium welchii* which produces several toxins, some in excess of others, according to the conditions to which it is exposed. This multiplicity of toxins is reflected in the different diseases set up by infection with this micro-organism. It was known for a long time that it was an important cause of gas gangrene of toxic origin in the human subject, but it was only after diseases of sheep were studied that strains were found capable of producing several toxins, the individual toxins or a mixture of them causing the different sheep diseases. In lamb dysentery, one of the toxins is present in excess of the others. Infection takes place through the alimentary canal, the bacteria multiply in the stomach and intestine, where the toxins cause severe ulceration and absorption of the toxins takes place. Death is the usual sequence to the infection. In older lambs, excess of another toxin gives rise to the condition known as "pulpy kidney disease", so called from the changes observed in the kidneys soon after death.

Immunizing Against Bacteria and Toxins

These diseases can now be prevented to a large extent by immunization against the infecting bacteria and their toxins. This may be carried out in three ways: antitoxins, produced mostly in horses, can be used on young susceptible lambs and sufficient immunity is conferred on them to carry them over the susceptible period; lambs may be immunized through their mothers; for the protection of older lambs against pulpy kidney disease, direct immunization with vaccine may be carried out. Probably the most interesting result of the research work on these diseases is the transmission of immunity from the mother sheep to the lamb. Although a pregnant sheep may be highly immunized against these anaerobic toxins, her lamb is born quite free from any immunity and in a highly susceptible condition. However, in immunized pregnant sheep, the protective substances accumulate in the udder to a high degree and, at its first suck, the lamb receives those protective substances which are absorbed through the intestine into the general system and thus immunity is acquired. These protective substances in the colostrum continue to be absorbed by the young lambs for several days, after which no further absorption takes place. This method of protecting young lambs is valuable in breeding flocks scattered over wide areas, where it may not be possible to handle newly-born lambs.

DISEASES OF THE RESPIRATORY TRACT

Throughout the world there are many diseases of poultry of economic importance which interfere considerably with the development of the poultry industry. Some of them are now capable of being controlled and the results are reflected in better poultry production. Newcastle disease has been discussed in a previous article. The modern conditions under which poultry are maintained are conducive to the spread of infections and considerable damage may ensue in the absence of adequate measures of control. A difficult problem concerns the diseases of the respiratory tract, because some confusion exists on their differentiation, their causal agents and, therefore, the methods of their control. The tendency has been to apply the term "chronic respiratory disease" of poultry to almost any condition in which there was evidence of disturbance of the respiratory tract, including the air sacs. It has now been shown that several infectious agents may give rise to diseases of the upper and lower respiratory tract which, although specific, have very similar clinical symptoms and, further, that more than one infection may be present in the same fowl at the same time, when secondary complications have arisen. These various infections, however, can be differentiated by laboratory methods and so, the picture of poultry respiratory diseases is becoming clearer. The group includes infectious catarrh or coryza, infectious bronchitis, infectious larynge-tracheitis, sinusitis of turkeys, Newcastle disease, other mixed infections and true "chronic respiratory disease".

Need to Identify Infecting Agent

For a long time the specific nature of chronic respiratory disease was doubted because of the failure to recognize the true causal agent and the association of pathogenic pleuro-pneumonia-like organisms (PPLO) with respiratory disease in general. Research and experiments have now shown clearly that virulent PPLO alone may infect the respiratory tract and cause symptoms and lesions which may resemble those caused by other infectious agents. In some respects the clinical picture of some of these diseases may be very similar and laboratory examinations may be necessary to ascertain which disease is present. For some of the infections, curative and preventive treatment is available in the form of medicaments and vaccines. It is essential, however, to know the exact nature of the infecting agent, for a treatment which can be successfully applied to one may be of little value in others. In addition, emphasis must be given to the application of strict sanitary measures, including satisfactory disposal of dead fowls, and cleansing and disinfection of promises occupied by infected birds. Strict precautions should also be taken to prevent the introduction of any of the infections into healthy flocks by infected fowls or contaminated materials.

Treating Poultry Infected with Fowl Pox

Fowl Pox, caused by a virus which produces symptoms and lesions affecting the respiratory tract and the skin, is still of economic importance in some regions and it is often necessary to adopt protective measures to prevent its occurrence and spread. Affections of the respiratory tract due to fowl pox are sometimes confused with other diseases and, in the absence of skin lesions, tests should be carried out to establish the true cause.

Satisfactory protection against fowl pox is obtained by the use of vaccine prepared from the causal virus. Formerly, it was necessary to "grow" the virus on the combs and parts of the skin of susceptible fowls and collect the lesions produced. Now the virus for vaccine production is usually cultivated in the developing chick embryo of fertile eggs. The virus of pigeon pox has also been used as a vaccine for protection against fowl pox: while considerable protection is afforded, the duration of immunity is comparatively short and its use has largely been replaced by vaccine containing fowl pox virus.

How to Apply Vaccines

The application of the vaccine is carried out in different ways. It may be applied by scarifying a small area of the skin usually on a leg from which the feathers have been plucked and rubbing in a small quantity of the vaccine: it may also be applied by the "wing-stab" method, in which a sharp needle or somewhat similar instrument, dipped in the vaccine, is used to pierce the web of a wing, a quantity of the vaccine being left behind in the pierced skin. It is always necessary to ascertain if the vaccine has "taken": a number of the treated fowls should, therefore, be examined on the third or fourth day after vaccination when the appearance of the treated skin should give positive indications by swelling of feather follicles of the treated area in the leg or by swelling of the skin surrounding the "stab" in the wing web. Very young chicks may be treated and successfully protected. Following the use of vaccine containing the live virus of fowl pox, an immunity of long duration results.

In this series of articles, only some of the infectious diseases of animals and poultry have been discussed. Many more are of considerable importance; space, however, will not permit their discussion.

NEED FOR EARLY DIAGNOSIS

In the diseases mentioned, little has been written on detailed symptoms nor on the methods and tests used for the diagnosis. This was done on purpose because an accurate diagnosis is essential before satisfactory methods of control can be applied. Veterinarians have the knowledge and experience to make the necessary diagnoses and to know when laboratory tests are required. The need to consult veterinarians on diseases of animals in their early stages cannot be over-emphasized. By so doing, there is every likelihood that the animal owner will benefit in many ways and the spread of a serious disease throughout a country may be prevented.

Animal owners can, of course, make important contributions to the prevention and control of diseases by practising good hygienic and management methods and by isolating at once any animal showing obvious signs of illness.

REVIEWS

FARM PROFITS AND COSTS NJORO AREA 1958/59, by B. R. Davidson and W. J. England, Agricultural Economics Survey Report No. 1, 1959, 52 pages, obtainable from Egerton Agricultural College, Njoro, Kenya. Price Sh. 2/50.

This, the first of the bulletins by the staff of Egerton Agricultural College, Njoro, deals with an Agricultural Economics Survey in Kenya. It is a study of the causes of farm profits and losses in the Njoro area during 1958/59. The authors stress that the results apply only to one year, so that the main value of the work will lie in its use for comparison with later studies. Nevertheless, they arrive at some interesting conclusions, among these are that high profits per farm are associated with the larger farms while livestock farming rather than crops seemed a safer measure of ensuring some profit.

MACHINE MILKING, Bulletin No. 177 of Ministry of Agriculture and Fisheries, London, 1959. Obtainable from Her Majesty's Stationery Office, London, 195 pages, 32 illustrations, 56 figures. Price 12*s*. 6*d*.

The milking machine is now an important item of equipment in many dairy farms. This bulletin deals with all its aspects. The chapter headings are: Anatomy and Physiology of the Udder, Engineering Aspects, Use of the Milking Machine, Milking Machines and Mastitis, Hygiene and Rubber. Under Engineering Aspects the modern milking machine is described in some detail and proprietary products are used to illustrate the text, while notes on installation and maintenance are also included. The long chapter on Milking Machines and Mastitis, among other things, deals with the controversy about the effect of machines on udder health and it gives an excellent summary of present knowledge about such matters.

This bulletin should be in the hands of all dairy farmers, and in particular of those who are contemplating the switch from hand to machine milking.

THE CHEMICAL COMPOSITION OF THE GRASSES OF KENYA—II

By H. W. Dougall and A. V. Bogdan, The Grassland Research Station, Department of Agriculture, Kitale, Kenya

(*Received for publication on 16th September, 1959*)

The purpose of growing the grasses of Kenya in our nursery at Kitale and of examining their chemical composition at a specific stage of growth viz. the early flowering stage, have already been explained (I). In this second paper we give in alphabetical order, a brief description of a further 49 different grasses together with a note on their distribution and an assessment of their palatability and of their probable feeding value. In this series crude protein ranges from 5.66 to 19.66 per cent, crude fibre from 22.43 to 43.32 per cent, Ca from 0.15 to 1.05 per cent, and P from 0.08 to 0.27 per cent, all values being expressed on a dry matter basis.

Andropogon canaliculatus Schumacher.—A tufted perennial 6 in. to almost 3 ft. in height which occurs in seasonal swamps. It is common in Western Kenya and at the coast. It does not produce a great deal of bulk and only occasionally does it form a noticeable portion of a sward. Our analysis shows that this grass is relatively rich in protein and that it is not unduly fibrous. It is also adequately supplied with Ca and P.

Arthraxon serrulatus Hochst.—A tufted perennial up to 2 ft. in height with characteristic ovate leaves unusual in a grass. It occurs only occasionally on rocky ground. Analysis shows that it is a useful source of protein but field observation shows that it is not well liked by cattle.

Beckeropsis procera Stapf.—A tufted perennial 2 to 5 ft. in height which occurs mainly on the crater slopes of Menengai and Longonot where it often forms the main bulk of the herbage. It has very numerous, thin, wiry stems and the relatively low nutritive value of this grass may be ascribed to its very fibrous character and to its low protein content.

Bothriochloa insculpta (Hochst. *ex* A. Rich.) A. Camus.—A perennial 1 to 3½ ft. in height which forms spreading tufts and also produces stolons if it is grazed low. It occurs on seasonally waterlogged black clay soils at medium and lower altitudes and it may form almost pure stands. At the early flowering stage it is rather stemmy and its protein value is relatively low.

Brachiaria lachnantha (Hochst.) Stapf.—A tufted perennial 1 to 3 ft. in height which occurs on seasonally waterlogged black clay soils in not very large but isolated colonies. This grass has a large proportion of leaves and its stems are not hard. Analysis shows that this grass is rich in protein and that it is not fibrous. It provides a useful source of Ca and P.

Brachypodium flexum Nees.—A tufted perennial 1½ to 3 ft. tall which occurs within forests, close to their edges, at altitudes over 6,000 ft. It is rich in protein and, despite its numerous stems, it is not unduly fibrous.

Capillipedium parviflorum (R. Br.) Stapf.—A tufted perennial 1½ to 3 ft. in height with aromatic panicles. This grass is rare in Kenya and it has been recorded only in Nairobi. It is a fibrous grass, low in protein and in phosphorus.

Chloris amethystea Hochst.—A stoloniferous perennial 2 to 3 ft. in height which forms slowly-spreading colonies from short stolons and produces numerous thin stems. This grass is abundant at Marsabit where it is one of the main grazing grasses: in other parts of Kenya it occurs only occasionally. It is relatively rich in protein but fibrous, and it is a useful source of calcium and phosphorus.

Chloris mossambicensis K. Schum.—An annual or perennial stoloniferous grass up to 2 ft. in height and of very similar habit to that of *C. amethystea*. It is common at the coast where it forms extensive colonies but it is rare in other parts of the territory. This grass is a good source of protein and it is not unduly fibrous. It is well supplied with Ca though not with P.

Chloris myriostachya Hochst.—A tufted perennial 1 to 4 ft. in height. It is common in the arid and semi-arid parts of Kenya and especially towards the coast where it often forms a considerable portion of the sward. This grass is rich in protein and it is a useful source of P.

Cymbopogon validus Stapf. *ex* Burrt Davy.—A tufted perennial 4 to 10 ft. in height which is common in the upper woodland and the lower forest zone of Mount Kenya. The leaves of this grass are slightly aromatic. *C. validus* is tough and fibrous.

Dactyloctenium aegyptium (L.) Beauv.—An annual grass up to 2 ft. in height with soft, succulent leaves. It is widespread in Kenya below 6,500 ft. and occurs in pastures in arid areas and as a weed in cultivations. It is rich in protein and in calcium and it is relatively low in fibre.

Dichanthium annulatum (Forsk.) Stapf.—A tufted perennial 2 to 4 ft. in height which occurs occasionally in grassland on rocky ground. This grass is usually coarse and stemmy and in consequence its nutritive value is low.

Dichanthium papillosum (Hochst. *ex* A. Rich.) Stapf.—A tufted perennial very similar in appearance to *D. annulatum*. It occurs mainly on seasonally waterlogged plains with black, clay soils. The nutritive value of this grass is low.

Digitaria macroblephara (Hack.) Stapf.—This is probably one of the few forms of *D. milanjiana* that are specifically not very distinct. The sample analysed belongs to a type that is common in the arid and the semi-arid parts of Kenya where it is much valued as a grazing grass. It forms small tufts but it may also spread by creeping stolons. Our analysis shows that this grass is a very useful source of protein.

Digitaria scalarum (Schweinf.) Chiov.—A rhizomatous perennial common in Kenya's grassland at various altitudes. It may also occur as a troublesome weed in cultivations. *D. scalarum* is a nutritious grass, well liked by cattle but it does seem to lack vigour.

Digitaria ternata (Hochst. *ex* Steud.) Stapf.—This annual is ubiquitous as a weed of cultivated land. It contains a useful amount of crude protein and it is not fibrous.

Digitaria velutina (Forsk.) Beauv.—This annual also is a widespread weed and of similar nutritive value to *D. ternata*.

Eleusine jaegeri Pilger.—A tufted perennial forming broad tussocks in grassland throughout the Kenya highlands. The tough fibrous leaves with their sharp edges make this grass unpalatable.

Eragrostis braunii Schweinf.—A tufted perennial 1 to 3 ft. in height which usually occurs in grassland on stony ground. Its stemminess is reflected in the high crude fibre value shown by our analysis.

Eragrostis tenuifolia Hochst. *ex* A. Rich.—An annual or short-lived perennial up to 2 ft. in height which forms small, tough tufts. It is common in overgrazed pastures and may be found as a weed in cultivations, especially in leys. It is usually left ungrazed by stock for some reason which cannot be explained by chemical analysis.

Harpachne bogdanii Kennedy O'Byrne.—A tufted perennial up to 2 ft. in height which occurs within a limited area between Embu and Kitui. This grass is a good source of protein but it is very fibrous.

Harpachne schimperi Hochst. *ex* A. Rich.—A tufted perennial up to 1¼ ft. in height which is common in overgrazed or otherwise mismanaged pastures. This grass is stemmy but the stems are not hard. Despite its high content of crude protein and its not unduly high content of crude fibre, this grass is not liked by cattle.

Hyparrhenia diplandra (Hack.) Stapf.—A robust tufted perennial 4 to 8 ft. in height or even taller, with thick fibrous stems and broad leaves. Our analysis of the whole plant shows that it is a poor source of protein and that it is somewhat fibrous. Field observation however shows that grazing animals strip and eat the leaves of this grass and leave the stems untouched.

Hyparrhenia dissoluta (Nees *ex* Steud.) C. E. Hubbard.—A tufted perennial up to 7 ft. in height which is very common at medium altitudes and at the coast. In its very early stages of growth this grass is completely grazed, but at later stages the stems are usually left ungrazed and only the leaves are eaten. Our analysis of the whole plant at the early flowering stage is surprisingly favourable.

Leptochloa obtusiflora Hochst.—A medium-sized tufted perennial common from the coast to about 3,500 ft. altitude, in dry bush. The leafiness of this grass varies considerably and the more leafy plants such as those of which our sample was composed are very rich in protein and are not particularly fibrous. They are well supplied with Ca and P.

Leptochloa rupestris C. E. Hubbard.—A rhizomatous perennial with numerous fine stems and numerous short leaves. It occurs on stony ground in the West Suk district. Our analysis shows that this grass is a useful component of the sward.

Lintonia nutans Stapf.—A stoloniferous perennial up to 3 ft. in height which occurs in seasonally waterlogged black clay soils in arid and in semi-arid areas. Analysis shows that this grass is a very useful source of protein and of minerals although field observation suggests that *L. nutans* is not highly palatable to stock.

Loudetia arundinacea (Hochst. *ex* A. Rich.) Steud.—A tufted perennial reaching to more than 7 ft. in height. It occurs mostly on soils with impeded drainage or in rocky places. This grass is often leafy when young. Our analysis shows that it is relatively rich in protein but somewhat fibrous.

Loudetia flavida (Stapf.) C. E. Hubbard.—A tufted perennial 1 to 3 ft. in height. It occurs in the northern part of the Rift Valley Province and it is particularly common in the West Suk district, in bush and often on rocky ground. This grass is fibrous though it is a useful source of protein.

Melinis tenuissima Stapf.—A tufted perennial with numerous fine and wiry stems and numerous short leaves which occurs in Western Kenya, e.g. in the Trans Nzoia district. This grass does not seem to be liked by stock.

Panicum infestum Anderss. *ex* Peters.—A tufted perennial forming broad, rather low tufts although the flowering heads may reach up to 4 ft. It occurs at the coast where it is common and also at altitudes up to 5,500 ft. This grass is readily eaten by cattle. Our sample contained almost 18 per cent of crude protein and it was not fibrous. Ca and P within the grass reached useful levels.

Panicum masaiense Mez.—A tufted perennial forming cushions up to 2 ft. and occasionally 4 ft. in height. It is a valuable grass in arid parts of Kenya and it is well liked by stock. Our sample on analysis gave a remarkably high crude protein value together with a low crude fibre value. Unfortunately the seeding quality of this grass is rather poor, a fact which makes its introduction as a cultivated grass very difficult.

Panicum trichocladum Hack. *ex* K. Schum. —A creeping and rambling perennial with numerous short lanceolate leaves which occurs in bush and forest edges at the coast. It also occurs in highland forest in areas of high rainfall. This grass is valued by the Kikuyu and it is well liked by their cattle. Our sample had a crude protein content of nearly 10 per cent but it was somewhat fibrous.

Pennisetum dowsonii Stapf. & C. E. Hubbard.—A perennial with long, spreading stems which occurs in swamps and on the margins of lakes in high altitude areas. It can grow well as a cultivated grass under much drier conditions and it is well liked by cattle, though its nutritive value would not appear to be high.

Pennisetum glabrum Steud.—A rhizomatous perennial with short rhizomes also forming loose tufts. It occurs in grassland under moist conditions. The leaves of *P. glabrum* are tough and this tends to reduce the palatability of the grass though it contains adequate protein.

Pennisetum trachyphyllum Pilger.—A tall perennial with rambling or semi-erect, rather thick stems and large leaves. It occurs at forest edges and in forests, often forming dense stands along the banks of streams. The leaves of this grass are readily eaten by cattle but the stems are left untouched. Our analysis of the whole plant suggests that it is a useful source of protein.

Pogonarthria squarrosa (Licht.) Pilger.—A tufted perennial with wiry stems up to 3 ft. in height. It occurs in arid or semi-arid parts of Kenya, mostly on poor, sandy soil. Our analysis indicates that it is a useful source of protein but since it is stemmy, and fibrous, its palatability is relatively low.

Rhynchelytrum repens (Willd.) C. E. Hubbard.—A tufted, usually short-lived perennial characteristic of fallows and of old cultivations. The panicles are pink at the flowering stage. Our sample contained over 11 per cent of crude protein, but field observation suggest that *R. repens* is not highly palatable.

Rhynchelytrum scabridum (K. Schum.) Chiov.—A tufted perennial forming low cushions with flowering heads up to 2 ft. in height. It occurs occasionally in semi-arid areas. As might be anticipated, it is somewhat fibrous.

Rhynchelytrum subglabrum (Mez.) Stapf. & C. E. Hubbard.—A tufted perennial forming loose cushions with numerous short leaves. It occurs on rocky ground, mainly in the West Suk district. Though adequately supplied with protein this grass is fibrous.

Setaria chevalieri Stapf. and C. E. Hubbard.—A tall tufted perennial up to 8 ft. high or even taller with large, not numerous leaves which are folded fan-fashion. It is common in forests and at forest edges. The leaves of this grass are eaten occasionally by cattle. Our analysis of the whole plant suggests a grass of relatively low nutritive value.

Setaria phragmitoides Stapf.—A tall, reed-like grass which occurs in grassland, in bush and also in seasonal swamps. This fibrous grass is usually avoided by stock.

Sporobolus africanus (Poir.) Robyns & Tournay.—A perennial grass of high-altitude grassland which forms small tufts up to 3 ft. in height. Although it is relatively rich in protein, this grass is fibrous and of low palatability.

Sporobolus angustifolius A. Rich.—A tufted perennial forming loose tufts 2 to 3 ft. in height. It occurs mainly in grassland and bush in Western Kenya. This grass provides a useful source of protein and minerals and it is not unduly fibrous.

Sporobolus helvolus (Trin.) Dur. and Schinz.—A perennial which spreads by long stolons and also forms small tufts. It is common in arid and semi-arid areas and occurs in seasonally waterlogged black clay soils or in volcanic ash. It is one of the best grazing grasses of these areas.

Sporobolus? *longibrachiatus* Stapf. (A. B. 2993).—A tufted perennial 9 in. to 2 ft. in height, common in open grassland between Nairobi and Lake Magadi. This grass is rich in protein and relatively low in crude fibre.

Tricholaena eichingeri (Mez.) Stapf. & C. E. Hubbard.—A tufted perennial forming loose cushions; the pink or white panicles reach 1 to 2 ft. in height. This grass occurs in semi-arid areas in grassland and bush, often on rocky ground. Its chemical composition is very satisfactory but we know little about its palatability.

Urochloa bolbodes (Steud.) Stapf.—A tufted perennial up to 3 ft. in height which occurs in open grassland and in bush, mostly in the West Suk district. This grass, which contains almost 14 per cent of crude protein and is not unduly fibrous, is very palatable.

REFERENCE

(I) Dougall, H. W., and Bogdan, A. V. (1958). *E. Afr. agric. J.*, *24*, 17.

THE CHEMICAL COMPOSITION OF THE GRASSES OF KENYA

(*per cent of dry matter*)

BOTANICAL NAME	1959 Date Harvested	Ash	Crude Protein	Ether Extract	Crude Fibre	Carbo-hydrate	Ca	P
Andropogon canaliculatus	8 May	9·84	13·26	2·02	31·86	43·02	0·30	0·23
Arthraxon serrulatus	24 June	8·77	10·06	1·51	34·21	45·45	0·62	0·18
Beckeropsis procera	24 June	6·14	6·84	1·12	43·32	42·58	0·15	0·14
Bothriochloa insculpta	24 June	8·19	7·95	1·45	32·62	49·79	0·32	0·12
Brachiaria lachnantha	11 May	10·87	15·54	2·80	27·08	43·71	0·31	0·27
Brachypodium flexum	19 May	10·24	17·87	2·16	32·26	37·47	0·32	0·17
Capillipedium parviflorum	24 June	7·23	6·88	0·93	36·80	48·16	0·32	0·10
Chloris amethystea	22 May	8·60	12·99	0·74	36·08	41·59	0·46	0·22
Chloris mossambicensis	26 May	9·48	13·76	1·82	31·68	43·26	0·63	0·16
Chloris myriostachya	22 May	8·78	16·12	0·90	30·79	43·41	0·36	0·20
Cymbopogon validus	14 Aug.	10·55	6·96	1·97	38·77	41·75	0·23	0·12
Dactyloctenium aegyptium	11 May	9·96	15·83	1·83	26·82	45·56	1·05	0·12
Dichanthium annulatum	24 June	6·89	8·53	1·14	38·98	44·46	0·30	0·15
Dichanthium papillosum	26 May	7·32	8·88	1·65	38·61	43·54	0·25	0·10
Digitaria macroblephara	24 June	11·22	12·34	1·79	32·16	42·49	0·44	0·18
Digitaria scalarum	18 May	9·48	14·70	3·75	28·95	43·12	0·44	0·21
Digitaria ternata	26 May	8·87	11·52	3·37	28·32	47·92	0·32	0·16
Digitaria velutina	18 May	10·29	10·53	2·54	27·10	49·54	0·43	0·20
Eleusine jaegeri	26 May	6·02	10·47	2·39	34·81	46·31	0·36	0·17
Eragrostis braunii	8 May	8·86	12·85	2·43	35·53	40·33	0·28	0·21
Eragrostis tenuifolia	11 May	6·84	10·94	2·40	32·47	47·35	0·30	0·24
Harpachne bogdanii	26 May	7·09	11·92	2·15	40·52	38·32	0·41	0·15
Harpachne schimperi	11 May	8·51	15·02	2·79	29·73	43·95	0·41	0·26
Hyparrhenia diplandra	14 Aug.	9·01	5·66	1·76	36·42	47·15	0·40	0·09
Hyparrhenia dissoluta	18 May	8·80	12·94	3·00	33·71	41·55	0·25	0·19
Leptochloa obtusiflora	22 May	9·53	18·44	1·66	27·95	42·42	0·62	0·22
Leptochloa rupestris	9 July	9·10	12·15	1·71	33·26	43·78	0·31	0·19
Lintonia nutans	8 May	9·56	13·67	2·56	31·48	42·73	0·47	0·21
Loudetia arudinacea	22 May	9·25	14·37	1·63	34·81	39·94	0·25	0·16
Loudetia flavida	8 May	10·83	9·78	2·73	35·33	41·33	0·37	0·16
Melinis tenuissima	9 July	7·68	9·92	2·32	33·39	46·69	0·32	0·19
Panicum infestum	27 April	15·41	17·79	1·95	26·09	38·76	0·68	0·23
Panicum masaiense	11 May	10·73	19·66	2·51	23·98	43·12	0·33	0·22
Panicum trichocladum	11 May	8·48	9·55	2·54	35·05	44·38	0·18	0·12
Pennisetum dowsonii	9 July	6·01	9·31	1·10	32·23	51·35	0·20	0·20
Pennisetum glabrum	11 May	7·80	10·81	2·68	31·67	47·04	0·24	0·17
Pennisetum trachyphyllum	14 Aug.	10·41	10·15	1·97	29·96	47·51	0·26	0·19
Pogonarthria squarrosa	22 May	10·58	11·80	2·73	33·51	41·38	0·40	0·16
Rhynchelytrum repens	26 May	9·84	11·30	2·26	31·84	44·76	0·40	0·20
Rhynchelytrum scabridum	26 May	9·37	9·54	0·62	33·24	47·23	0·25	0·20
Rhynchelytrum subglabrum	26 May	7·95	11·71	1·93	34·30	44·11	0·21	0·19
Setaria chevalieri	14 Aug.	12·11	8·33	1·81	33·54	44·21	0·31	0·08
Setaria phragmitoides	24 June	10·04	9·88	0·82	37·83	41·43	0·21	0·14
Sporobolus africanus	8 May	8·19	14·79	3·21	34·06	39·75	0·30	0·22
Sporobolus angustifolius	8 May	11·85	14·05	2·93	29·11	42·06	0·36	0·21
Sporobolus helvolus	24 June	10·33	12·87	0·79	30·63	45·38	0·47	0·16
Sporobolus ? longibrachiatus	14 Aug.	12·18	16·23	2·25	22·43	46·91	0·48	0·25
Tricholaena eichingeri	26 May	17·42	14·59	2·67	31·38	33·94	0·40	0·24
Urochloa bolbodes	26 May	10·55	13·72	2·79	30·01	42·93	0·28	0·17

THE ARTIFICIAL CULTURE OF THE EDIBLE EAST AFRICAN OYSTER, CRASSOSTRAEA CUCULLATA (BORN)

By V. D. van Someren, Ministry of Forest Development, Game and Fisheries, Kenya Colony

(*Received for publication on* 28*th October*, 1959)

Because of increasingly heavy exploitation of the few natural edible oyster beds on the Kenya coast, and the apparent lack of any natural regeneration, an investigation was made of the biology and cultural possibilities of this oyster in 1953/54 (van Someren and Whitehead, *in Press*). The full report of this investigation is still awaiting publication at the time of writing the present paper (October, 1959), but since the main investigation was completed, experiments have been in progress in subsequent years into the cultural aspects. The results of these now appear to be worth recording for the benefit of the trade, without awaiting publication of the full report.

PREVIOUS WORK

As a basis, the main findings of the 1953/54 investigation can be summarized as follows:—

(1) The edible oyster *C. cucullata* of the East African coast is an entirely intertidal species, growing only in a narrow zone at average mid-tide level on both coral rock exposures and mangrove roots. It is polymorphic, and probably divisible into either races or species on biological grounds. The "spiked" oyster, growing at higher levels on mangrove roots, is almost certainly a separate species.

(2) A continuous low level of spawning activity occurs throughout the year, but there are also two maximum spawning periods coinciding with the onset of the twice yearly rainy seasons. These are probably governed by (*a*) maximal water temperatures over 29.5°C., (*b*) the immediate onset of rain and (*c*) a fall in salinity, all acting in conjunction.

(3) The length of free-swimming life of the larvae is not known, nor the size at first settlement as spat. Spat always settles in the normal intertidal zone of the adult oyster. Maximum spat fall occurs during the rainy seasons of November/December and April/May, the latter providing the heaviest spat-fall.

(4) Growth of settled spat averages about 0.6 cm. a month at Mida Creek, and mortality of settled spat appears very low. In seven months, such spat can grow to the average adult oyster length of 4-5 cm., but such young oysters do not thicken until their second year, reaching marketable size in two-and-half to three years.

(5) Settlement of spat appears almost negligible on natural substrates in any area, but spat can be collected readily on artificial collectors, the best type of the latter being either oyster shell culch or mangalore tiles. Artificial culture appears an entirely practicable proposition, and is indeed essential if harvesting of oysters continues at the present high rate, both to preserve the natural beds and to provide adequate yields for the market.

METHODS

It is not intended here to recapitulate the various culture devices which were tried at the time of survey. Attention has since been concentrated on the two forms which appeared then most promising, shell culch and tiles.

The early experiments suggested that pierced oyster shells strung on wires at the appropriate tide level, in the form of a "Japanese Umbrella", were efficient collectors. Although at first they collected mainly barnacle spat, the first umbrella erected, later collected a heavy crop of good quality oysters.

Accordingly, in December, 1957, several more such collectors of various patterns were installed in the experimental area in Mida Creek, pierced shells being strung in various ways, with and without bamboo spacers, at the appropriate tide level. In spite of the early success of these methods, these later trials have proved a complete failure. The shells became heavily fouled with barnacle spat within only a few months of erection and have remained so ever since, no oyster spat whatever settling on them. They have proved tedious to instal, though not expensive, and have not proved so suitable for maintainance as was first supposed, the wires sagging and breaking after a short time. Use of shell culch is not therefore now recommended. If strung, it is clearly too attractive to barnacles; if laid on the ground it very soon becomes silted over and unsuitable for any oyster settlement.

Trials with mangalore tiles have, however, been continued both at Mida Creek and Kilifi Creek among natural oyster beds, and it now appears that these are entirely suitable, and a relatively cheap and long-lasting form of collector.

At Mida Creek, whole or part tiles have been stacked in leaning rows among the mangrove stilt roots in the oyster bearing zone, and though left unattended for a year at a time since 1955, the rows have proved remarkably stable. A few have collapsed into stacked piles, thus restricting spat settlement to a certain extent, but with larger rows and more frequent attention, this could easily be prevented.

At Kilifi, as described in the full report, rows of tiles have been placed at various tide levels, over various substrates, in 1955 and 1956; these tiles were supported between poles to keep them upright. Those erected broadside on to the waves collapsed within a few weeks and were rebuilt end-on to the waves. Even these have proved difficult of maintainance, collapsing frequently until in 1958 the various rows had almost completely lost their original entities.

It has now become apparent, however, that nothing so elaborate is required, spat settlement being just as satisfactory among collapsed tiles at Kilifi; and if tiles are merely laid on their edges among the coral rocks in sufficiently large, broader bands, these will be sufficiently stable to be fully efficient as collectors on both their sides without any special supporting structures. Naturally somewhat closer attention to their disposal than the once yearly attention we have given them would be more satisfactory, and any concessionaire thus undertaking artificial culture should obviously bear this in mind.

RESULTS

These tile devices at both Mida and Kilifi have been examined in August each year since 1956, counts of oysters per 10 tiles in each of the Kilifi rows being made until these lost their identity in 1958; at the same time measurements of 100 oysters selected at random from each row of tiles were reconstituted on a length frequency basis to determine spatfall and possible age-grouping.

The initial disposition of the Kilifi rows is indicated in Fig. 1, the "A" rows being over a muddy substrate, and rows "B" to "I" being on a rocky reef outcrop bearing plentiful natural oysters.

Figure 2 shows the counts of oysters per tile from each row, averaged from ten tiles in each row, for each year, since 1956. As the rows became disarranged, it became impossible to separate the results, only rows "B" and "C" still being distinguishable as such in 1959. A few bundles of six tiles wired together were placed in the position indicated in Fig. 1 in October, 1958, but otherwise no new tiles were added to the rows after 1956, nor were any of the existing tiles ever cleaned or replaced.

By reference to Fig. 1, certain conclusions are evident from the results graphed in Fig. 2.

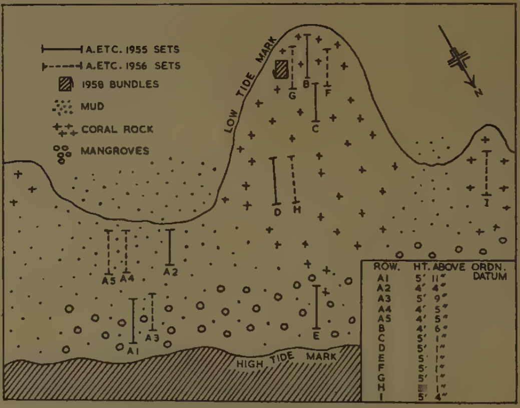


Fig. 1.—Sketch plan (not to scale) of tile collector sets, Kilifi Creek

(1) Spat settlement is at all times far less over a muddy substrate than over rock, though in the "A" rows, it is of interest to note that rows A1 and A3, placed slightly higher up the beach than other "A" rows, at the outer edge of the mangrove fringe, have collected more oysters than the lower "A" rows. This is probably not connected with the level at which the rows were placed, but with the fact that the two higher rows were over a more firm substrate, with a greater admixture of sand, than the three lower rows.

(2) Of the rows placed on the rocks, in general those at the lower level have collected more oysters than the higher rows.

(3) Provided the tiles are not completely smothered in mud, their state of cleanliness is apparently immaterial. Thus the tiles in row "B" which had remained quite uncleaned since 1955, had still in 1959 collected more spat than they did in their first year (Fig. 3), though in appearance they were distinctly "dirty" with various encrusting organisms such as seaweeds, spirorbids and a thin film of greyish silt. It is now known in fact that cleanliness of culch is not so important as was first thought in early oyster culture work, and that a certain amount of organic fouling is known to be necessary for good spat settlement (Yonge, *personal communication*).

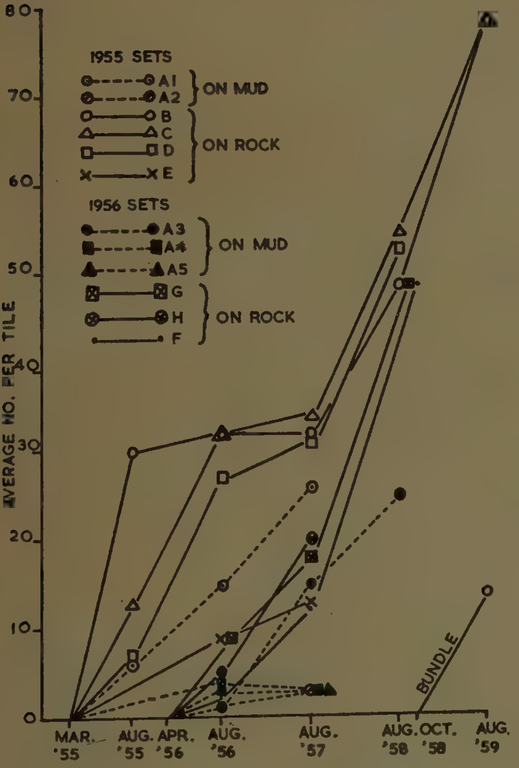


Fig. 2.—Oyster counts on tiles, Kilifi Creek

There can also be no doubt that although barnacles will certainly settle and grow on tiles, such settlement is minimal compared with that on shell culch for example. Barnacle settlement on tiles, even in the four years of observation, has never been very heavy and this does not in any way appear to affect oyster settlement or growth.

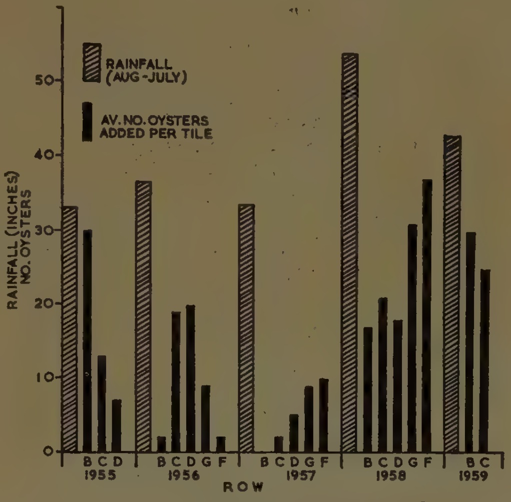


Fig. 3.—Yearly rainfall and oyster settlement, Kilifi Creek

It also appears from Fig. 2 that taking oysters per tile as an indication of annual spatfall, some years have been poor spat years, others good. This trend is not completely correlated from row to row, but it would seem that spatfall in 1956 and 1957 was poor compared with that in 1958 and 1959. The previous work had indicated a relationship between spatfall and rainfall, and Fig. 3 shows that, although an exact correlation is not evident, the years of heavier rainfall (calculated from August one year to July of the next at the nearest rain gauge to the Kilifi oyster beds, Kibarani Agricultural Station) have resulted generally in a greater number of oysters being added per tile.

Since, however, some spawning occurs all the year round, and the growth of settled spat is remarkably fast, the length frequency distributions of oysters each year do not show any clear cut age-group pattern which might be expected from the counts per tile (Fig. 4).

The two measurements in 1956 at only three months' interval, shown in Fig. 4, were not grouped in the same way as latter data; but they clearly show the rapid growth of spat, the young oysters of 0.1 to 1.5 cm. being dominant in the April count just after maximum spatfall, this pattern of dominance changing to the larger 3.0+ cm. in rows "B" and "C" as the oysters have grown. Thereafter, in succeeding years, the pattern becomes more confused. The ten-month old crop of oysters on the tile bundle also shown in Fig. 4 shows a normal length distribution of oysters at this age.

It has been known from oyster work in other countries that spatfall is not necessarily related to spawning, a good spawning season not necessarily leading to a good spat settlement, and obviously there are many complex factors at work which, with observations such as these at long intervals of a year each, would preclude any more detailed interpretation of the overall picture. Nevertheless for practical cultural purposes, it would seem that good rains will increase the crop of oysters, and a poor spatfall will probably occur in years with a rainfall of less than say 40 in. on this part of the coast.

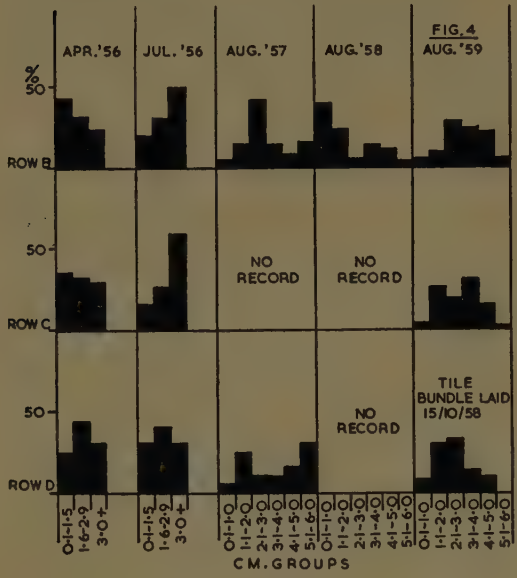


Fig. 4.—Per cent length frequency of oysters on tiles, Kilifi Creek

PRESENT RECOMMENDATIONS

Because of the irregularity within the overall pattern, and a constant low level of spawning, it does not now appear necessary to place tiles at any particular time of the year. Lots can be placed at any time, and given good rains during the succeeding periods, they will continue to collect and grow oysters for at least four years and probably many more. Any form of really gross fouling or silting will probably militate against good oyster settlement, but actual cleaning of tiles would not seem necessary, though it is probably useful after say four years or so to chip off the adherent lower shell valves as well, in case these become too attractive to barnacles; but for shucking up to that time, only the upper valves need to be removed, not the whole oyster. At the moment it is not recommended to do more than lay tiles, collect spat and harvest in the area in which spatfall has occurred. Tiles should be laid nearer the lower edge of natural oyster beds. Generally it should be noted that oysters are usually more watery and of poor quality in June/August, being largely spent. Batches of tiles can be carried to above high tide for shucking and then replaced.

Oysters on tiles are much easier to shuck than those either on mangrove roots or on rocks, since they are "on the flat" as it were, and only the upper shell needs to be detached, the meat spooning out clean. There is no need to detach and crush the whole shell; thus washing, which removes the tasty liquor, can be minimal.

In October, 1958, some clean tiles were placed at both Kilifi and Mida, which had been wired together in bundles of six, the bundles being stood on edge. These bundles have not shown any greater stability than rows of tiles placed on edge in sufficient breadth, nor has the spatfall on them been any greater; so that the additional work in making up such bundles is not justified.

Under normal creek conditions such as prevail in the sheltered creeks of Mida, Kilifi and Port Reitz, the tiles if placed in sufficiently closely packed rows on their long edges have a very low rate of breakage and will certainly last for several years each. It is not necessary for tiles to be complete; a half tile collects as many spat in relation to its surface area as does a whole tile.

Tiles with corners broken are readily obtainable on the coast at little cost, certainly not more than 50 cents each or much less, since they are of little value for any other use. As a test of the economics of such culture, in September, 1959, 11 tiles were taken from the vicinity of rows "B" and "C" at Kilifi. From these 11 tiles, one half-pint of oysters was shucked, the meats counting at 244 to the half-pint; a further 496 oysters remained on the tiles, these being generally considered too small to be harvested.

This count of meats is high, but not more so than that of the concessionaire who has worked both Mida and Kilifi for several years, who averages about 450 meats to the pint from each of these areas. The Port Reitz concession yields much bigger oysters at 240 meats to the pint. The harvesting there is selective and careful, and it is possible that Port Reitz is in general more fertile with a great deal more organic waste available from port and other drainage, this leading to bigger oysters.

It would clearly pay in a culture area to collect only the larger oysters from a larger number of tiles, leaving the others to grow. Taking the lower figures evident from this survey, it would appear that from any one tile after four years, only one-third of the oysters are croppable, i.e. from tiles averaging 80 oysters each, such as these, only 30 are big enough to shuck. At 450 meats to the pint, therefore, 15 tiles are required to produce one pint of oysters.

Supposing an area is expected to yield on an average about two pints a day, or say 600 pints a year, this would then require 7,000 tiles to be laid, at a capital cost of say £170, with broken tiles at 50 cents each. Prevailing prices for dealers at the coast are roughly as follows; each pint of oysters costs about Sh. 7 to collect, this being the price paid to the collectors, with a fraction extra to cover transport, breakages and ice. One pint of oysters is then wholesaled at approximately Sh. 20. On the basis of these costs, 600 pints at Sh. 7 per pint for collection will cost £210, and sell at £600. Deducting from this selling price the cost of tiles, plus cost of collection, this leaves a clear profit for the *first* year of harvesting of £220. Thereafter, in subsequent years, since the capital cost of tiles is already recovered in the first year of harvest, the 7,000 tiles will yield a profit of £390 per year, if collecting and selling costs remain steady at the figures quoted. It seems unlikely that any further capital cost is required, since the tiles are almost indestructible, and apparently go on collecting for years. 7,000 tiles, laid on edge in rows, cover an area of little less than half an acre. As stated, these figures are at the lower level of the present findings; they can be scaled up or down according to capital available, and are probably lower than would occur in actual practice, since cropping must of course be on a continuous basis if the market is to be supplied; these figures are calculated on a once yearly yield at any one time of 600 pints, which is unrealistic. The speed and ease of collection off tiles must be considered, as well as the higher quality of meat obtainable, which would be greater if at least monthly attention was given to tile stacking and arrangement—our own attention, on which these yields have been calculated, has been minimal; but such attention clearly does not require expensive labour.

FURTHER WORK

Obviously yields would be improved and profits rise, the larger the oysters are, and the more one can grow per tile. Our present experiments have shown almost the minimum which can be achieved by almost complete neglect of the collectors.

Increased settlement per tile could certainly be achieved by more attention to the tile rows, so that spat settlement can take place fully on each side, by turning the tiles from time to time.

Experiments are now in progress to determine whether greater fattening and growth of these oysters can be attained under conditions of total submersion instead of twice daily exposure as is normal. Tiles bearing measured oysters of all sizes are now being held hanging from buoys at various levels in deep water in both Malindi Bay and Kilifi Creek. Results both from the technical and cultural point of view are not yet available.

There has, however, been some indication that such totally submerged growth may in fact be much better; and also that, contrary to previous findings, oyster larvae can settle on certain substrates below lowest tide level, even under apparently rather unfavourable conditions. On 26th March, 1959, the Fishery Division's wooden MFV Menika 1 was beached in Kilifi Creek, scrubbed clean and two coats of anti-fouling paint applied. 89 days later, after two days at sea, 15 in Mombasa Harbour, and the remaining period of time at anchor in Kilifi, the ship was again beached, and considerable numbers of oysters scraped from her bottom below the water-line. Most of these were about 3.5-4.0 cm. in length, but some were as big as 5.5 cm., and big enough to be edible.

Apart from the fact that the anti-fouling paint had not deterred these larvae from settling, or killed those which did, this observation indicates two important facts, firstly that spat of *C. cucullata* can under certain circumstances settle on objects held submerged below lowest tide level, and secondly that growth under subsequent total submersion can exceed that occurring at normal intertidal levels.

As already indicated, 1959 appears to have been a good spatfall year, which may explain settlement in such unusual places. To test the possibilities, clean collectors have also been buoyed in deep water in Kilifi Creek, together with tiles already bearing oysters, in order to see if such spat settlement can occur normally under water at any time.

SUMMARY

Following on a previous full investigation of the biology of the East African edible oyster, *C. cucullata*, it is now shown that artificial culture of these on mangalore tiles is a fully practicable proposition, and will in time become essential if exploitation is to continue at its present high level. The techniques as at present known are described in detail, spawning and spatfall being governed to a large extent by the annual rainfall. Experiments to modify and increase yields and growth are still in progress.

ACKNOWLEDGMENTS

I am gratefully indebted to Mr. T. E. Allfree, Provincial Fishery Officer (Coast) of this Ministry, who has at all times shown the deepest and most practical interest in this problem, and who was personally responsible for erection, early maintainance and some of the measuring work at Kilifi; and whose knowledge of the trade and its economics has been placed freely at my disposal. Mr. P. J. Whitehead, Research Officer (Fish) of this Ministry has also closely co-operated with me in the field work involved, and to him also my thanks are due.

REVIEWS

EFFICIENT USE OF FERTILIZERS, F.A.O. Agricultural Studies No. 43, Food and Agriculture Organization of the United Nations, Rome, 1958, 355 pages. Price 22*s.* 6*d.*

This publication is an enlarged and revised edition of Monograph No. 9 in the series of F.A.O. Agricultural Studies. The changes take into account much of the work on fertilizers during the past decade. Chapter 9, which is new, discusses 31 major world crops, their physical soil requirements, their nutrient demands, their widest distribution and general fertilizer needs.

All agricultural officers who are concerned with fertilizer experiments should have a copy of this publication if only to read and re-read Chapter 5 which deals with the factors affecting the use of fertilizers and manures. These are succinctly discussed under the headings of Soil, Climatic and Crop Factors as well as Systems of Farming and Fertilizer characteristic and efficient use.

This work is likely to be in constant demand for reference purposes until it is replaced by a new edition.

INDUSTRIAL FIBRES, 1959 (No. 9). 224 pages. Price 10*s.* net (10*s.* 10*d.* post free). Obtainable from H.M. Stationery Office, or from the Secretary, Commonwealth Economic Committee, 2 Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

Industrial Fibres presents in convenient form reviews of production, international trade, consumption, stocks, prices and customs duties for the following commodities: wool, cotton, rayon and other man-made fibres, mohair and other fine hair, silk, flax, jute and jute manufactures, sisal and other hemps, coir and kapok. The present volume covers, in detail, developments up to the close of the 1957/58 season, while at the same time comparisons are given for earlier post-war seasons as well as for the average of the five immediate pre-war years. In each section particular reference is made to the part played by the Commonwealth countries, and to their interests, whether as producers or consumers.

The present edition (the ninth in the post-war series) contains not only all the regular features of earlier editions brought up to date, but also much new material.

THE EFFECTS OF FOUR MANAGEMENT TREATMENTS ON TEMPORARY LEYS

By R. Strange, The Grassland Research Station, Department of Agriculture, Kitale, Kenya

(Received for publication on 18th September, 1959)

The influence of pasture management on the botanical composition, productivity, and nutritive value of grassland is widely recognized elsewhere, but our knowledge of this subject under local conditions in Kenya is still rather limited, especially in relation to temporary pastures consisting of grass/legume mixtures. One of the most important problems in the management of such pastures is the maintenance of a satisfactory balance between grass and legume. Kenya white clover appears to be a particularly difficult component to control since under favourable conditions of soil and climate, it tends to dominate the grasses, and is sometimes viewed with disfavour by farmers for this reason.

The effects of management on the balance of species in mixed swards that include Kenya white clover have been studied at Kitale over a period of four years and the results of this work are reported here.

EXPERIMENTAL

In 1955 four grasses, Nzoia rhodes (*Chloris gayana*); commercial molasses (*Melinis minutiflora*), slender guinea (*Panicum maximum* var. *trichoglume*) and Nandi setaria (*Setaria sphacelata*) respectively, were drilled in 3 ft. rows in mixture with Kenya white clover. "Provence" lucerne seed was drilled between each row of the grass/clover mixture, resulting in alternate rows 1½ ft. apart. Establishment was satisfactory though the slender guinea grass was thin in places. Each of these four grass/legume mixtures was drilled separately in adjacent blocks and the following treatments were applied to each of them in a "grid" arrangement:—

Treatment 1. Frequent grazing by a large concentration of stock, followed by mowing to about 4 in. above the ground.

Treatment 2. Less frequent grazing by a large concentration of stock followed by mowing.

Treatment 3. Less frequent grazing by a large concentration of stock without mowing, except for a clearance cut to achieve uniformity at the start of each season. The object of this treatment was to allow the grasses to develop a tall "stool" initially by delaying the first grazing of each season, so that all subsequent re-growth throughout the year could be grazed at a relatively high level above the ground. The average height of the herbage was about 9-12 in. in the molasses and rhodes grass mixtures and 12-18 in. in the setaria and guinea grass mixutres.

Treatment 4. The removal of the first flush of each season for silage or hay, followed by Treatment 3 throughout the remainder of the experimental year.

The experimental year is the period between the beginning of the rainy season (approx. 1st April) and the end of March of the following year.

The animals used were a varying number of Zebu and pedigree Red Poll cattle and they were turned into the fields whenever growth was judged to have reached the correct stage in accordance with the prescribed treatment. The fields were heavily stocked on each occasion and the available herbage was generally consumed in 1-2 days.

The average number of grazings per experimental year for each treatment are shown in Table I. These averages include the establishment year which gave fewer grazings than in subsequent seasons.

TABLE I

Treatment 1	Treatment 2	Treatment 3	Treatment 4
7	5	6	Silage + 4

The treatments were duplicated and the plots were fenced separately in paddocks of about two-thirds acre each. In each of these paddocks, the four grass/legume mixtures were grazed simultaneously as it was not possible to manage them individually owing to the smallness of the area. This resulted in a certain amount of selective grazing which, together with the differential growth rate in the grasses, masked slightly the management effects on the molasses grass and more severely the effects on the rhodes grass. Nevertheless, certain treatment effects on the composition of the swards were clearly discernible. All plots were mown at the beginning of each season to achieve uniformity. After the removal of tall weeds during the establishment year, no further weeding was attempted.

Fertilizers were applied as shown in Table II.

TABLE II

Year	Pounds per Acre		
	Triple Super-phosphate	Ammonium Sulphate	Gypsum
1955–56 ..	200	112	—
1956–57 ..	56	112	—
1957–58 ..	56	112	168
1958–59 ..	56	112	168

There was no visible response to gypsum as judged by the state of the control strips which were left in each treatment.

Prior to each grazing, a visual estimation of the percentage of grass, clover, lucerne and weeds in each mixture was made independently by different persons. Their estimates were combined to give an average.

Estimations of the dry matter production from each grass mixture in treatments 1 and 2 were obtained by means of quadrat cuts taken before each grazing. During the first two seasons the area sampled was 900 square feet, but this was reduced to 450 square feet during the last two seasons.

Mature cow grazing days were recorded in each treatment. It was not possible to leave the animals in the paddocks overnight but an approximate estimate of the complete grazing days was made as follows:

$$\frac{\text{Total daylight cow grazing hours}}{8} \times \frac{5}{8} = \text{cow grazing days},$$

since it has been found in animal behaviour studies on this station that a cow grazes for approximately eight hours out of the 24; and that five-eighths of the grazing period occurs during eight hours of daylight.

RESULTS

The effect of management on botanical composition.

The influence of the four different managements on the species composition of the pastures, recorded during each season, is shown graphically in Fig. 1. Treatments 1, 2 and 3 lead to a decline in the proportion of grass and lucerne, and to a steady increase in the proportion of pioneer grasses and weeds; but whereas the proportion of Kenya white clover rises steeply in Treatment 1, it rises less steeply in Treatment 2, and remains more or less constant in Treatment 3. Treatment 4 produces a marked increase in the proportion of grass during the first season, but by the end of the experiment, this component had reached approximately its original value. The proportion of lucerne falls steeply during the first season but thereafter remains fairly constant. Here again there is a steady rise in the proportion of pioneer grasses and weeds, but the proportion of clover remains constant after the first season.

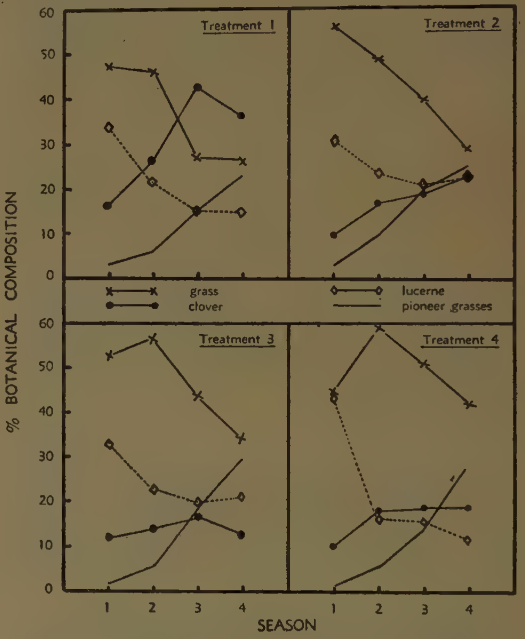


Fig. 1.—Showing the effects of different treatments on the botanical composition of the swards over four seasons. For explanation see text

In addition to these changes in species composition, which were common to all mixtures, some interesting differences occurred between mixtures in the proportions of their component species. These differences are illustrated by the data in Table III in which the mean composition of each mixture is shown, under Treatments 1 and 2.

Thus, the clover combined well with rhodes, setaria and guinea grass, but less well with molasses grass. This was probably due in part to the dense clumps which are normally developed by this species and which are difficult for the clover to penetrate. This reluctance of molasses grass to form a homogeneous combination with white clover has also been observed in other trials at Kitale. There was a comparatively high proportion of white clover in the guinea grass mixtures, which may be accounted for partly by the slow development of the grass seedlings during establishment, and partly by the relative thinness of the stand, which permitted the clover to predominate from the start of the experiment.

TABLE III.—THE MEAN PROPORTION OF SPECIES WITHIN MIXTURES

(*visual estimation of percentage*)

Species	Treatment 1				Treatment 2			
	Grass	Clover	Lucerne	Weeds	Grass	Clover	Lucerne	Weeds
Molasses ..	44	16	25	15	47	7	28	18
Rhodes ..	33	26	25	16	39	16	26	19
Setaria ..	47	32	17	4	59	14	22	5
Guinea ..	22	48	19	11	30	31	24	15

The lucerne grew slightly better with molasses and rhodes grass than with Nandi setaria and slender guinea.

Nandi setaria excluded weeds far more successfully than the other grasses.

It was clearly noticeable that where the clover had become dominant as a result of Treatment 1, both slender guinea and Nandi setaria had recovered during their fourth season, by the end of which they had occupied about the same percentage of the sward as they did in their fisrt season. This effect is illustrated by Table IV.

TABLE IV

% Composition	1955–56	1956–57	1957–58	1958–59
Grass	43	34	24	40
Clover ..	26	43	57	35

The recovery by these grasses may be due to their use of legume nitrogen which by then had probably become available in sufficient quantity to improve their growth. A similar recovery did not occur in the rhodes or molasses grass mixtures, probably because in the first place there was insufficient clover with the molasses grass and secondly because the Nzoia rhodes grass was not persistent. In its first year it occupied 50 per cent of the sward but in its fourth year it occupied only 5 per cent.

The effect of management on yield of pastures.

The influence of each of the management treatments on the mean yield of the four mixtures, expressed in cattle grazing days per acre, is shown by the figures in Table V. An estimate of the average carrying capacity of the leys under each management is also shown.

TABLE V.—MEAN GRAZING DAYS PER ACRE

(*estimated mature cattle days of* 24 *hours each*)

Treatment	Mean cattle grazing days per annum	Mean estimated carrying capacity per beast
1	214	1·7 acres
2	204	1·8 acres
3	274	1·3 acres
4	Silage plus 162	—

Although stock grazing days cannot be relied upon as a precise measure of pasture productivity, these records supported by other observations made during the course of the experiment, suggest that certain trends may be attributed to the management of the pastures. Treatment 3, for example, consistently gave the highest number of stock grazing days per acre. As mentioned earlier, however, the amount of clover was reduced by the coarse growth of grass, and uniformity of the sward was largely sacrificed. Treatment 1 generally permitted a heavier stocking rate rate than Treatment 2 and resulted in a pasture of apparently higher nutritive value. Treatment 4, i.e. removal of the first flush of growth for ensilage or hay, caused a marked decline in the productivity of the leys in the last season.

Dry Matter Yields and Chemical Composition of the Herbage.

The mean annual dry matter yield from Treatments 1 and 2 are given in Table VI.

TABLE VI.—THE MEAN ANNUAL DRY MATTER YIELDS

(*Cwt. per acre*)

Season	Treatment 1		Treatment 2	
	Sown Species	Sown species and Pioneer Plants	Sown Species	Sown species and Pioneer Plants
1955–56 ..	37·0	38·0	33·3	34·2
1956–57 ..	44·3	46·7	42·7	46·2
1957–58 ..	38·6	44·5	36·5	44·6
1958–59 ..	32·9	41·0	40·0	51·8
Mean ..	38·2	42·6	38·1	44·2

It is seen that throughout the course of the experiment the yields of dry matter remained fairly constant. Clearly there are no differences in yield due to treatment and the mean yields of 42.6 and 44.2 cwt. per acre respectively suggest a carrying capacity of about 1.8 acre per beast. This accords well with the estimates given in Table V for these two treatments.

It is noteworthy that although there was a distinct decline in the estimated yield of the sown species after the second season, which occurred chiefly in rhodes and molasses grass, the total yield was maintained at a more or less constant level by the steadily increasing fraction of pioneer species which supplemented the grazing.

The mean annual yield of conserved material obtained from the first flush of each mixture in Treatment 4 varied between 19.3 cwt. of dry matter per acre in the Nandi setaria mixture and 14.3 cwt. per acre in the slender guinea grass, but it should be remembered that these yields were obtained following the annual application of sulphate of ammonia. The average crude protein content of this dry matter varied between 11.56 per cent in the Nandi setaria mixture, which generally contained a higher proportion of stem, and 13.38 per cent in the slender guinea grass. The protein content of the cut material of all mixtures dropped from a mean of 15.17 per cent and 16.41 per cent in the first and second years respectively, to 10.26 per cent and 9.02 per cent in the last two seasons. These values compare favourably with that of 11.34 per cent quoted by Woodman [1] for good meadow hay in Great Britain.

Discussion and Conclusions

The effects of the four treatments on the botanical composition of the herbage have already been described. Although Treatment 1 tended to favour Kenya white clover at the expense of grass and lucerne, the sward did not lose its uniformity and become coarse and tufted as was the case with Treatment 3 in which the residues remaining after grazing were not removed by mowing. The development of coarse clumps, which generally occurs in pastures which are not periodically mown, encourages greater selectivity amongst the animals, with the result that clover tends to become strongly dominant in patches of short herbage where the animals have concentrated, while it is more or less eliminated from the coarser patches of grass which the animals largely ignore.

It is therefore considered that a satisfactory balance between grass and Kenya white clover might best be achieved by carefully controlling the grazing and by periodic close mowing to maintain the uniformity of the sward. Thus, if it is desired to encourage a spread of clover, the frequency of grazing should be increased, preferably by making use of high stock concentrations to obtain a more even utilization of the pasture. If it is desired to suppress the clover, the intervals between grazing should be prolonged sufficiently to allow the grass to gain ascendency over the clover.

The results of this experiment have shown that the four grasses differ in their ability to combine with Kenya white clover, and molasses grass appears to be inferior to the other three species in this respect. Both Nandi setaria and slender guinea rejuvenated after an initial period of dominance by the clover, and provided evidence to show that clover dominance in some circumstances may be only a passing phase.

The strongest growth of clover occurred in the slender guinea mixtures where the population of grass was relatively low. This illustrates an important point, which has also been observed elsewhere, that satisfactory control of the grass/clover balance becomes more difficult, and the danger of clover dominance—and of bloat in cattle—considerably increased, when too low a population of grass seedlings has been established in pasture mixtures.

The lucerne on the whole persisted reasonably well for four seasons and deserves consideration as a pasture legume under these conditions.

It has been noted on the basis of animal grazing days that Treatment 3 carried the greatest number of stock, although it is likely that the quality of the herbage was not adequate to meet the requirements of high yielding cows. The mean carrying capacity of the leys under both Treatments 1 and 2 was estimated at 1½-2 acres per mature beast. It appears that under these conditions mixed leys may be expected to provide an average of about 6-8 grazings in a season, or a grazing every 6-8 weeks during the main period of growth if they are stocked heavily for short periods.

It was noted that a steady increase in the proportion of pioneer grasses and weeds helped to maintain the carrying capacity of the leys during the latter period of the experiment.

The mean annual yield of conserved material from the first flush of the leys was over 15 cwt. of dry matter per acre, and contained an average of 12 per cent of crude protein.

Reference

[1] Woodman, H. E., Bull. No. 48 (1957). Her Majesty's Stationery Office, London.

RAINFALL INTERCEPTION BY A TROPICAL FOREST IN UGANDA

By B. Hopkins, University College, Ibadan, Nigeria

(*Received for publication on 11th November, 1959*)

For many years a controversy has raged as to whether or not there is greater rainfall over forests than over surrounding non-wooded areas, Geiger (1957) Kittredge (1948) states that in temperate regions local rainfall increase in forests may be up to 3 per cent and that rainfall in forest clearings may be about 1 per cent more than in the open. In addition there has been argument as to how much of the rain falling on a forest is intercepted by the canopy. For temperate forests a certain amount of data have been collected relating rainfall interception to species of tree, season and intensity of rainfall. In general it has been found that the proportion of the rainfall intercepted decreases as the intensity of the rainfall increases: Delfs (1955), Hoppe (1896) quoted in Geiger (1957), and Ovington (1954).

Throughout one year Vaughan and Wiehe (1947) compared the rainfall in three gauges in an upland tropical forest in Mauritius with that in a clearing about 1.3 km. away. They found there was considerable variation but for the year as a whole about two thirds of the rain recorded at the exposed station was recorded in the forest rain gauges. Whilst pointing out that there were large variations between their forest rain gauges and that rainfall is sometimes extremely local they state that "relatively more rain reaches the forest floor during the . . . heavy downpours than . . . when the rain is less heavy". Their claims were similar to the above mentioned results for temperate forests.

Analysis of their monthly data shows that there was a good correlation between the rainfall recorded in their forest rain gauges and their exposed station rain gauge ($r = 0.9094$, $p < 0.001$). Hence they are justified in making their comparison. The correlation between their exposed station monthly rainfall and the mean proportion of this recorded in their forest rain gauges is insignificant ($r = -0.4580$, $p > 0.1$). However, this may well have been significant if the daily, instead of monthly, data had been analysed.

The only other tropical data known to the author are those of Freise (1936) from forests in Brazil termed "subtropischen" which were "probably not very different in structure from Tropical Rain forests" (Richards, 1952). Two localities, just over 500 km. apart, were studied and in each locality observation posts were set up in a forest clearing, near the forest edge and well within the forest. At each forest post there were two rainfall gauges, one 1.5 m. above ground level and the other attached to the top of the trunk of the highest tree from which the branches had been removed. These rainfall gauges were recorded daily for 27 years in one locality and for 21 years in the other. The mean annual rainfall recorded at 1.5 m. above ground level varied from 29.8 per cent to 34.8 per cent of that recorded in the crowns.

When most of a month's rain fell as thunder showers 26.7 per cent (not 24.7 per cent as quoted by Richards) of the crown rainfall reached the 1.5 m. rainfall gauge, whereas when most of a month's rain was in the form of long continued fine rain, 35.5 per cent reached the ground. These data are, as Richards points out, at variance with those of Vaughan and Wiehe (1947). They are also at variance with results from temperate regions.

Observations by the author on the rainfall reaching the ground in an area of high forest and a neighbouring area of savanna woodland at Olokemeji in south-western Nigeria have yielded results which cannot be simply interpreted.

During a recent visit to Uganda an opportunity arose of obtaining some useful data on this subject.

Mpanga Research Forest

The observations were made in the Mpanga Research Forest, Uganda. This forest is intersected by 0° 12′ 30″ N. latitude and 32° 17′ 30″ E. longitude, it is 16 km. north of Lake Victoria and 40 km. west of Kampala and lies at 1,160 m. altitude.

The mean annual rainfall at Mpanga is about 1,130 mm. and it occurs mainly during two wet seasons each year. There are two to four months when the rainfall is below 50 mm.

The temperature varies from 10° C. to 33° C. and the relative humidity from 60 per cent to 95 per cent.

The vegetation of the reserve is essentially similar to that of the catena (about 2 km. to the south of it) described by Thomas (1945, pp. 24-30).

During August, 1958, the East African Virus Research Institute erected a 120 ft. high tower in this forest in order to investigate the microclimate and insect movement. The tower was so sited that no tree felling was necessary during its construction. This tower lies about 300 m. west of the Forest Station at Mpanga where the official rain gauge and a Dines gauge are located. The forest surrounding the tower has an incomplete upper canopy at about 30 m. mainly composed of *Pseudospondias microcarpa* (A. Rich.) Engl., *Erythrina excelsa* Baker, *Piptadeniastrum africanum* (Hook. f.) Brenan together with lianes, especially *Entada gigas* (Linn.) Fawcett and Rendle. There is an understorey chiefly composed of *Strombosia schefferi* Engl. and *Trichilia rubescens* Oliv. which together with the upper layers forms an almost complete canopy. The dense herb layer is predominantly *Dracaena fragrans* (Linn.) Ker-Gawl.

Methods.—A 7.6 cm. diameter glass funnel inserted in a 250 ml. conical flask was used as a "rainfall gauge"; the rainfall (in mm.) being equal to 0.22 times the volume of rainwater (in mls.) in the flask. Preliminary experiments (in Nigeria) had showns that evaporation from this apparatus was very slight and, even during the dry season, was negligible if readings were taken weekly. It had also been found that a layer of ground nut oil (or similar substance to reduce evaporation) was unnecessary and indeed undesirable as it made volume of rainwater determinations difficult and it was a source of attraction to ants.

Four rainfall gauges were placed on the ground one being about 2 m. away from each of the four corners of the tower. Rainfall gauges were also attached to poles which projected about 1 m. from the east, south and west corners of the tower at heights of 9.2 m., 18.3 m., 27.4 m. and 36.6 m. (30′, 60′, 90′ and 120′). (There were anemometers on the north corners of the tower at these heights.)

The volume of water in each flask was recorded on each visit. Seven visits at roughly weekly intervals were made during the period 25th March to 1st May, 1959, thus giving six observation periods.

Results.—During these observations, which commenced at the beginning of the main wet season, the proportion of rain days was 0.49, the mean rainfall per day 4.84 mm. and the mean rainfall per rain day 9.95 mm. The general weather conditions were bright and sunny with heavy showers usually during the morning though this was atypical, most rain normally falling in the early afternoon. The rainfall intensity varied from 0.038 to 0.163 mm./min.

The rainfall data and calculations from them are shown in Table 1. On the sixth line of this table the rainfall at each height for the whole period of observations is shown as a percentage of the Mpanga rainfall. It will be seen that 66.4 per cent of the Mpanga rainfall reached the ground and that approximately all of the Mpanga rainfall reached the other heights; the mean rainfall for all heights (except 0 m.) being 103.4 per cent that of the Mpanga rainfall. 64.2 per cent of the rainfall recorded for all heights (except 0 m.) reached the ground.

The differences in the mean rainfall per observation period between Mpanga and the various heights on the tower were compared by *t* tests. There were no significant differences at any height. The correlations between the Mpanga rainfall and tower rainfall at the various heights were also calculated. The correlation coefficient was significant at all heights and very significant at 0 m. and 36.6 m. Thus the comparison of Mpanga and tower rainfall is justified.

For the comparison of the rainfall recorded at the different heights on the tower, the data were expressed as rainfall per day for each observation period. The relevant data are given on the lowest line of Table 1. The differences in mean rainfall between all adjacent heights and between all heights and the ground were compared by *t* tests. The results are given in Table 2, where it will be seen that there are no significant differences between any of the means and that the differences between adjacent heights are greater than those between the various heights and the ground. The correlation between rainfall and height was just significant ($r = 0.2392$, $p = 0.02–0.05$) but if the data for the ground were excluded then it was not significant ($r = 0.2139$, $p = 0.05–0.10$).

TABLE 1.—COMPARISON OF RAINFALL RECORDED AT VARIOUS HEIGHTS ON THE TOWER WITH THAT RECORDED AT MPANGA. (ALL RAINFALL DATA ARE EXPRESSED IN MM. DURING THE SIX OBSERVATION PERIODS THE TOTAL RAINFALL RECORDED AT MPANGA WAS 179 MM.)

Height on tower (m.)	0	9·2	18·3	27·4	36·6
Total rainfall recorded	435·6	560·8	532·4	530·9	597·3
Number of flasks	4	3	3	3	3
Total number of observations	22*	18	18	18	18
Mean rainfall per flask per observation period	19·8	31·2	29·6	29·5	33·2
Mean rainfall as a percentage of the Mpanga rainfall	66·4%	104·4%	99·1%	98·8%	111·2%
Comparison of Mpanga and tower means by *t* tests— *t*	0·3151	0·0385	0·0080	0·0106	0·1067
p	0·8–0·7	>0·9	>0·9	>0·9	>0·9
Correlation of Mpanga and tower rainfall— r	0·6253	0·4834	0·4897	0·5421	0·6421
p	0·01–0·001	0·05–0·02	0·05–0·02	0·05–0·02	0·01–0·001
Mean rainfall per day	3·2	5·1	4·8	4·8	5·4

*Flasks were missing on two visits.

TABLE 2.—COMPARISON OF THE MEAN RAINFALL PER DAY AS RECORDED AT THE VARIOUS HEIGHTS ON THE TOWER BY *t* TESTS

HEIGHTS COMPARED (M.)		*t*	p
lower	upper		
0	9·2	1·3176	0·1–0·2
0	18·3	1·1626	0·2–0·3
0	27·4	1·2041	0·2–0·3
0	36·6	1·4936	0·1–0·2
9·2	18·3	0·2123	0·8–0·9
18·3	27·4	0·0620	>0·9
27·4	36·6	0·3246	0·7–0·8

From the Dines gauge data the time during which rain fell in each observation period was determined and the rainfall divided by this gave the rainfall intensity. The correlations between the Mpanga rainfall intensity and the rainfall recorded at the various heights on the tower (expressed as a proportion of the Mpanga rainfall) were calculated. The correlation coefficients for both individual and combined heights were all insignificant. In Table 3 these data are shown when they were recalculated excluding the data for period 2 (in which 0.25 mm. (0.01″) of rain were recorded at Mpanga and insufficient to measure in the gauges on the tower). The correlation coefficients were again found to be insignificant except for the ground which was just about significant.

Finally, the differences between the mean rainfall recorded at the various corners of the tower were examined and found to be insignificant when calculated for both individual heights and for total.

TABLE 3.—CORRELATION OF THE MPANGA RAINFALL INTENSITY WITH THE MEAN RAINFALL RECORDED AT VARIOUS HEIGHTS ON THE TOWER AND EXPRESSED AS A PERCENTAGE OF THE MPANGA RAINFALL. (DATA FOR PERIOD 2 EXCLUDED)

Height on Tower (m.)	r	p
0	−0·8751	*c.* 0·05
9·2	−0·0200	>0·1
18·3	−0·2890	>0·1
27·4	+0·2772	>0·1
36·6	−0·0784	>0·1

DISCUSSION

These results show two things: first, that about 35 per cent of the rain falling on the forest is intercepted before it reaches the ground; secondly, that almost all this interception takes place between ground level and 9.2 m. height. The interception is caused by the herb layer. The results also suggest that there is a negative correlation between interception and rainfall intensity.

As previously pointed out the dense herb layer is predominantly *Dracaena fragrans*. This species has erect shoots about 1 m. high which have a spiral phyllotaxis. Approximately the basal third of the leaf is ascending and adaxially concave; the upper portion of the leaf is more or less horizontal (often with a descending tip) and is flat or even adaxially convex. Thus much of the rain falling on the basal third of the leaves will flow into their axils and down the stem.

The proportion of the rainfall intercepted at Mpanga is very similar to that recorded by Vaughan and Wiehe (1947) in Mauritius and considerably less than that recorded by Freise (1936) in Brazil.

The lack of correlation between the tower (above ground) rainfall (expressed as a percentage of the Mpanga rainfall) and the Mpanga rainfall intensity is to be expected as the rainfall on the tower and at Mpanga are not significantly different. The just about significant negative correlation between the rainfall recorded on the ground (expressed as a percentage of the Mpanga rainfall) and the Mpanga rainfall intensity is in agreement with data from the temperate regions and with those of Vaughan and Wiehe (1947) from Mauritius, but it is at variance with results of Freise (1936) from Brazil.

Obviously further data require to be collected and analysed. In particular, in the Mpanga Research Forest, it would be interesting to place rain gauges just above the herb layer and to extend the observations throughout the year.

ACKNOWLEDGMENTS

I am indebted to the Forest Department, Uganda, for allowing me to carry out these observations in the Mpanga Research Forest and for supplying me with information and assistance. In particular I would like to thank Mr. H. C. Dawkins for his interest in this work. Similarly I am indebted to the East African Virus Research Institute, Entebbe, for permission to use their tower. I also wish to thank Dr. E. M. Lind of the Department of Botany, Makerere University College, Kampala, for her interest and for the loan of apparatus.

REFERENCES

Delfs, J. (1955). *Mitt. Arbkreis Wald u. Wasser,* Koblenz *2,* 1.

Freise, F. (1936). *Petermanns Mitt. 82,* 301 and 346.

Geiger, R. (1957). *The Climate Near the Ground.* Trans. M. N. Stewart *et al.* Harvard.

Hoppe, E. (1896). *Mitt. a. d. forstl. Vers. wesen Osterr. 21.*

Kittredge, J. (1948). *Forest Influence.* McGraw Hill.

Ovington, J. D. (1954). *Forestry, 27,* 41.

Richards, P. W. (1952). *The Tropical Rain Forest.* Cambridge.

Thomas, A. S. (1945). *J. Ecol., 33,* 10.

Vaughan, R. E., and Wiehe, P.O. (1947). *J. Ecol., 34,* 126.

REVIEW

Some Aspects of Sprinkler Irrigation in Tropical Regions, by J. C. J. Mohrmann, Bulletin No. 2, issued by International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, 1959, 24 pages. Price $0.40.

This is a discussion of the value of sprinkler irrigation as well as a description of the practical aspects of the problem. The author concludes that sprinkler irrigation is chiefly a supplementary measure in the tropics and it is too expensive to apply throughout a dry season.

The bulletin should appeal to those who use supplementary water for the production of high-priced crops.

THE RIVER FISHERIES OF KENYA
PART II—THE LOWER ATHI (SABAKI) RIVER

By P. J. P. Whitehead, Ministry of Forest Development, Game and Fisheries, Kenya Colony

(*Received for publication on 2nd November, 1959*)

Whereas the river fisheries of Nyanza Province, to the west of the Kenya Rift Valley, are extensive and highly developed (Whitehead, 1959A), large parts of the eastward-flowing rivers of Kenya, e.g. the Athi and Tana rivers, remain virtually unexploited. The reasons for the lack of interest shown by the indigenous people settled near the middle and upper reaches of these two rivers are presumably sociological, since large and economically valuable fishes abound in all parts up to about 4,500 ft.

There are however, two fairly large fishing industries on the lower reaches of these rivers, the first operated by the WaGiriama of the lower Sabaki, and the second by the WaPokomo and associated riverine people on the lower Tana. The present paper summarizes the results of a fishery survey of the lower Sabaki carried out by the author in conjunction with Dr. V. D. van Someren, Senior Research Officer, during 1953/54. Occasional observations were made on the Tana river also, and these showed that the pattern of fishing closely resembles that found on the Sabaki but on a larger scale.

The eastern rivers provide an opportunity to attempt the controlled development of a virgin fishery, using experience gained on the lower reaches and in Nyanza Province. Work on the larger migratory fishes of the Tana river is being carried out at the Inland Fishery Research Station of this Ministry, and at the same time exploitation by various fishing methods is being investigated (van Someren, 1959). Thus development and control of the fisheries can be based on sound experience and knowledge.

THE SABAKI RIVER

The Sabaki, or Galana as it is sometimes called, is derived from the confluence of the Athi river and its tributaries, draining the eastern slopes of the Aberdare Mountains and of the Tsavo, draining the Kenya slopes of Mount Kilimanjaro. The two rivers converge at Tsavo, and the Sabaki flows eastwards with no further permanent additions during the final 120 miles to the mouth, which lies seven miles to the north of Malindi. From Shakama, 50 miles inland, the river descends about 300 ft., becoming increasingly sluggish and showing all the characteristics of a river which has reached a mature stage of development.

The Sabaki lies in a broad floodplain, in which permanent and temporary pools are common. Near the river the pools are filled mainly by flood water and they dry out between the rainy seasons. More permanent lakes occur higher up on the floodplain. These lakes, such as Chem Chem, Jilore, Merikano, Mbrikano and Mekimba (*see* Fig. 1) may in some cases be reached by high floods, but are usually maintained by rainfall and run-off.

The Sabaki estuary is short, salinities rarely exceeding 5 per 1,000 just above the Malindi-Mambrui road bridge, about a mile from the mouth. Such vertical water movements as occur above this point are probably due solely to a "backing up" of the river water at high tides. The tidal portion is lined with mangroves and the bottom is largely composed of fine mud and silt. At the mouth there is a small lagoon whose shape and position varies with the seasons. This lagoon provides a nursery for the juveniles of many estuarine fishes.

Flooding on the Sabaki is due almost entirely to precipitation over the upper reaches, local rainfall contributing little, although the freak rainfall in October, 1953 (14.41 in. in two days) was responsible for raising the level of Lake Jilore over three feet. At Malindi, rainfall averages about 30 in. a year, but is extremely variable and rapidly decreases inland, being roughly halved at Kakoneni, 20 miles from the sea. Two rainy seasons occur, the long rains extending from April to June, with May as a peak month, and the short rains occurring usually in October.

From Shakama to the sea the belt of riverine trees gradually widens, joining the Arabuko forest at Jilore, and much of the floodplain below this point is under cultivation. Reeds grow abundantly beside the river (mainly *Phragmites*, *Cyperus* and *Saccarum* spp.) but the river itself is sandy and lacks permanent aquatic vegetation. The lakes and floodpools (*ziwas*) on the other hand contain a dense flora

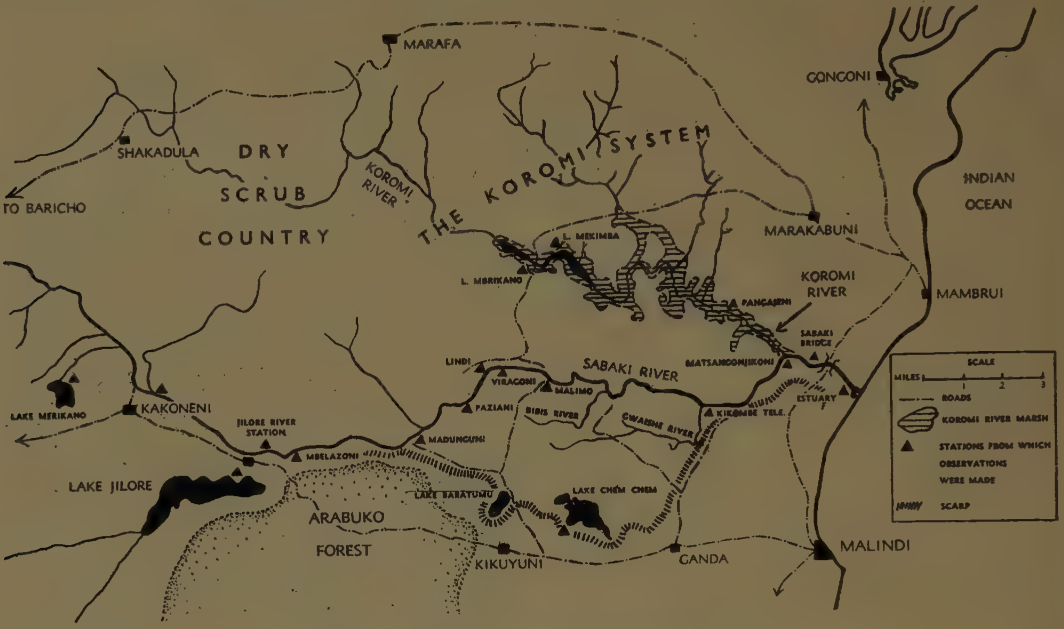


Fig. 1.—Sabaki River; area covered by survey

(*Nymphaea, Salvinia, Pistia* spp.) and are faunistically very rich. The river appears to act as a means of communication and as a refuge in the dry season for river fishes, whereas the lakes and *ziwas* are the breeding grounds and nurseries for many riverine species.

The Sabaki River Fishes

In contrast to the lower Tana river (Whitehead, 1959B) the lower 30 miles of the Sabaki river contain relatively few species of freshwater fish. Mormyrids and characids are entirely absent below Shakama, although both groups occur in the middle reaches. *Protopterus*, the Lungfish, and *Clarias*, the Catfish, are the largest of the Sabaki fishes, the latter attaining 10 or even 20 lb. in weight. Both are principally caught in the permanent lakes. The large "Mahseer" type of *Barbus* of the middle Athi and Tana are not found in the lower reaches, probably due to the absence of the swift, rocky conditions required for spawning. Two of the smaller species of *Barbus* occur, *B. zanzibaricus* and *B. taitensis*. Neither exceeds 10 cm. in length, but they are caught in large numbers in the lakes and *ziwas* together with juveniles of a third cyprinid species, *Labeo gregorii*, the adults of which may attain ¾ lb. in weight.

There are only two cichlid species in the Sabaki, *Tilapia mossambica* and *T. nigra*, the former being the most abundant. Specimens up to 20 cm. have been recorded, but the bulk of the catches in the lower Sabaki consist of juveniles and small adults of about 10 cm. Copley (1958) records fishes up to 4 lb. in weight.

Two small species of *Synodontis* occur, *S. zambesensis* and a closely related but smaller species, but in neither case do the adults exceed 6 oz. in weight, although considerable numbers are caught in streams during the rains. The only other purely riverine fish is *Eutropius* (near *E. depressirostris*) which may occasionally reach ½ lb. in weight.

Certain estuarine fishes appear in river catches, occasionally reaching as far up the river as Kakoneni. The commonest of these are the three euryhaline gobies, *Glossogobius giuris, Awaous aeneofuscus* and *Eleotris fusca*, all of which may perhaps have established purely freshwater populations. The Sea Catfish, *Arius africanus*, has been recorded at Jilore, and the pipefish, *Belonichthys fluviatilis*, is found in this area also. *Megalops cyprinoides*, the Tarpon, and *Chanos chanos*, the Milkfish, occur in the lower five miles of the Sabaki, especially near the mouth of the small Koromi river. The remaining estuarine fishes are mainly small juveniles (e.g. mullets) which are not exploited to any extent and rarely penetrate above the head of the estuary.

Finally, three species of freshwater eel are caught in the Sabaki, *Anguilla mossambica, A. bicolor bicolor* and *A. nebulosa labiata*, the latter being the most abundant. Such eels attain about 2-5 lb. in weight, although very much larger specimens have been caught in other parts of the river. Copley (1958) records an eel of 24.5 lb. from the Gura, a tributary of the Tana river. A single elver of *A. mossambica* has been caught in the lower Sabaki (van Someren and Whitehead, 1959) the first of this species to be caught in Kenya.

FRESHWATER PRAWNS

Prawns are abundant in the lower Sabaki and make a significant contribution to basket trap catches. Three main species occur, *Macrobrachium lepidactylus* being the largest, attaining as much as 40 gm. in weight. *M. rude* and *M. scabriusculum* are smaller but more commonly caught. The two species found in the Lake Victoria region, *Caridina nilotica* and *C. africana*, are present in the Sabaki but are not abundant. Four further species are occasionally caught, mainly in brackish water.

FISH MOVEMENTS AND BREEDING

Breeding occurs mainly during the two flood seasons. River trapping records have shown an enormous increase in the number of adult fishes in the river at the onset of the floods. Some of these may have vacated lakes or *ziwas* directly a link with the river had been established, but the majority of such fishes are probably derived from permanent upstream populations. Daget (in Johnels, 1954) discusses such longitudinal migration, which on the Niger takes place in the dry season, and terms it active, in contrast to a passive lateral migration from the river into the swamps in accordance with changes in water level. On the lower Sabaki however, the downstream movement of fishes at the onset of flooding appears more "passive" than the very large and striking migrations up small streams and channels into the lakes and *ziwas*.

Spawning may take place in the lakes, streams and *ziwas*, or occasionally in the main river itself. *Protopterus amphibius* breeds in lakes such as Lake Jilore, and is not found in the river or in the *ziwas*. *Clarias mossambicus*, found equally in the lakes, *ziwas* or main river, ascends and spawns in small streams connecting these habitats (Greenwood, 1955). *Labeo gregorii* and the two species of *Barbus* and *Synodontis* also ascend such streams, but spawn in the *ziwas* themselves, or in lakes. The two species of *Tilapia* appear to prefer the quieter conditions of the lakes for nest building, although breeding also occurs in the shallower parts of the river during the dry season. Nothing is known of the breeding habits of *Eutropius* in the lower Sabaki, but this species was not recorded in either the lakes or the *ziwas*. Ripe females were however caught half a mile up the Koromi river and it is possible that their breeding habits resemble those of *Clarias mossambicus*.

Of the estuarine fishes, *Glossogobius giuris* certainly breeds in *ziwas*, although in the Philippines this species is reported to spawn in brackish or marine waters (Blanco, 1958). Juveniles of the other two gobies have not been found, but yolked larvae of the Sea Catfish, *Arius africanus*, have been caught in a seine at the estuary.

Johnels (*loc. cit.*) showed that on the Gambia river there is a definite movement of fishes out of the swamps at the end of the flood season. On the Sabaki, adults with spent gonads have been recorded moving down streams shortly after the main upstream runs, but by the end of the rainy season the majority of *ziwas* have lost connexion with the river so that the juveniles at least must remain in the *ziwas* until the next flood. Desiccation, coupled with intensive exploitation with basket-traps and fish poisons, often results in the complete destruction of the *ziwa* stocks. Thus recruitment of river stocks must depend on unfished *ziwas* above Shakama, where settlement begins to thin out, or in dry years, on the larger and more permanent lakes.

FISHING METHODS

The fishing devices used by the Giriama are similar to those found elsewhere in Kenya, but perhaps owing to the small size of the Sabaki fishes, the traps and fences have a neatness, almost a delicacy of construction, not found in other areas. Fishing activities are carried out by the men and there is no counterpart to the scooping baskets operated by women, for example in Nyanza Province (Whitehead, 1958).

The principal method is the single basket-trap (Plate I). The traps are cylindrical, two to three feet in length and about eighteen inches in diameter. They are made from the branches of *mtsatsa* (*Acalypha fruticosa* (Forsk.)), stripped of their bark and bound on to hoops of *lushinda lume* (*Combretum constrictus* (Benth.) Laws). At one end the sticks are drawn together and tied firmly with another bark (*mubuma penga—Cissus rotundifolia* (Forsk.) Vahl.), and at the other an ingenious non-return funnel is inserted.

Plate 1.—Single basket-trap fixed in *uchigo*, Koromi River

Single traps are baited with *wishwa*, a stiff paste of boiled maize chaff wrapped in castor oil leaves, to which the leaves of a species of *Kedrostris* (*mavi mavi*) are added. The latter has an unpleasant odour which is said to attract fishes. To some extent the castor oil leaves may prevent premature disintegration of the *wishwa*, but it may be significant that some Uganda fishermen bait their traps with castor oil leaves alone.

Basket-traps are placed singly in the quieter stretches of the river, particularly near the reed beds, and they are anchored either by a long strip of bark or with two sticks placed on each side of the trap. Such traps are almost always placed facing downstream. They are also used in the *ziwas* and lakes.

Basket-traps (unbaited) are also employed in conjunction with fences or barriers (*uchigo*) in small streams during floods, or in the lakes and *ziwas*. A stout framework of branches is built to which matting of *mtsatsa* sticks or *Phragmites* stems is bound. Holes are cut at the bottom of the barrier every two or three feet and basket-traps are placed against the holes, occasionally on alternate sides to catch both up and down moving fishes. An *uchigo* is usually operated by three or four men, and the catch is shared.

In the shallower lakes and *ziwas*, *uchigo* take the form of long fences which are moved progressively as the water dries up until the fishes are confined in an area small enough to be fished efficiently with basket-traps. At the estuary another type of barrier is built, the *uzio*, a strongly constructed fence which is made in the form of a "W" so that fishes are guided into baskets on both the ebb and the flow of the tide.

Line fishing is commonly practised on the Sabaki, as well as on the lakes and *ziwas*. Most fishermen seem to prefer a weighted handline, although short rods are sometimes used. Hooks are baited with prawns, *wishwa*, insects or worms, and in the lakes the snail *Lanistes carinatis* is used for *Clarias* and *Protopterus*. At certain times of the year 50 or more men may suddenly descend on a lake and fish it intensively for a fortnight, catching quantities of small 10 cm. *Tilapia*, *Barbus* or *Labeo*. Long-lining, using two to three hundred hooks per line, is also practised on most lakes, the catch consisting mainly of *Clarias*.

Like some other Kenya tribes, the Giriama often spear fish, plunging the spear methodically into the deeper water near the banks and occasionally transfixing an unfortunate *Clarias*. Perhaps more rewarding are the fish poisons used in the *ziwas*. The principal poison is made from the bark of the *mtupa* tree (*Mundelea* sp.) which contains a high proportion of rotenone. Such poisons are prohibited, but probably have little effect on river stocks when used in the *ziwas*, since the latter are usually dry long before the next flood season. Gillnets, which play such a prominent part in the river fisheries of Nyanza Province, are not found on the Sabaki, although cast-nets and seine-nets are used at the estuary.

EFFORT AND YIELD

On the whole, fishing effort on the Sabaki is irregular, few men relying solely on fishing for a livelihood. Although nearly 200 individual fishermen were recorded during the course of the survey, the majority of these trapped only occasionally either with baskets or *uchigo* during the floods, or with lines in the lakes during the dry season. In some families one man may be permanently engaged in fishing and trap-making aided by relatives during the rains. On the larger lakes full-time fishermen are found, operating long-lines in conjunction with baskets. Fishing is mainly carried out by those living in the self-contained homestead or *midzi*, rather than by those living in the small villages.

River fishing tends to be restricted to the accessible areas near fords and watering places. Considering the numbers of families living near rivers or lakes, it is surprising how few actually indulge in fishing. Thus at Jilore, where at least 30 families live within a mile of both the river and Lake Jilore, there were never more than about six fishermen operating traps in the river at any one time. Usually one fisherman does not use more than four traps in the river. Fishing in the *ziwas* is also fairly light, about ten men trapping the four Jilore *ziwas*.

The greatest effort is found on the lakes and, at certain times of the year, in the streams. On the small Koromi river 28 small *uchigo* were seen in the lower two miles, while there were nearly 20 men trapping the first half-mile of this river in October, 1953. On the larger lakes 50 or more men may be found fishing in the dry season. On Lake Merikano, for example, there were five semi-permanent fishing camps in 1953, each camp with about five men operating about 20 traps in each camp, as well as using long lines. Regular long-line fishermen use between two and three hundred hooks per line.

The two main fishing seasons coincide with the floods. When, the river is in spate, river baskets are removed and *uchigo* are built in streams and channels. Later, as the water subsides, the *uchigo* are left and the baskets are replaced in the river. Some weeks often lapse before the *ziwas* are fished, apparently to let the muddy water clear, but perhaps also to ensure that spawning of *Labeo* and *Barbus* has taken place. Finally, as the *ziwas* dry out and river fishes become scarce, the fishermen turn to the lakes.

As would be expected, catch rates vary enormously both with the season and with the locality. In Fig. 2 monthly averages of catch per trapping day for a river basket-trap at Jilore are plotted with river heights, and this shows well the seasonal fluctuations in such river catches. Catches were higher during the

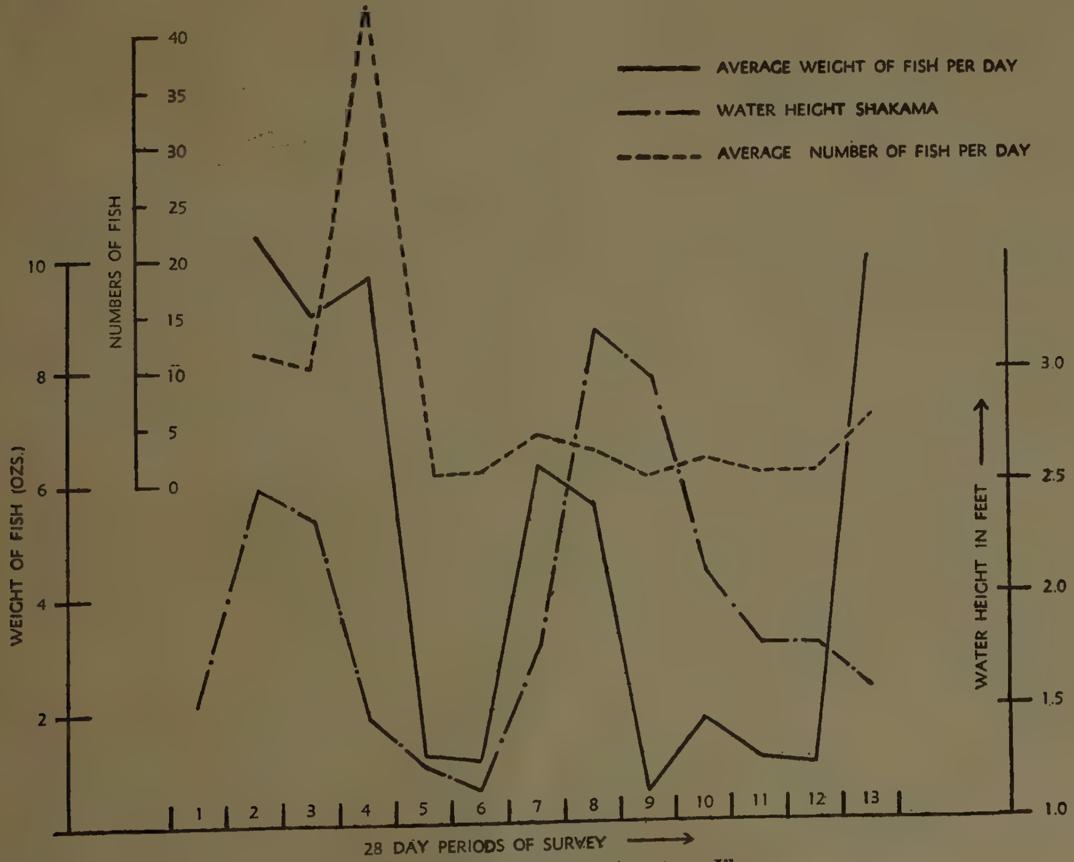


Fig. 2.—The yield from one river trap, Jilore

short rain floods of November and December (average 0.7 lb./trap/day during 42 recorded days) than in the April-March season (0.37 lb./trap/day for 41 days). The reason for lower yields in the larger flood may be that at this time more fishes were able to vacate the river and move into the *ziwas* and streams. Single basket-traps are however very inefficient, and an average catch rate of only 4.8 oz. per trap per day was recorded during 247 days of fishing by a trap in the river at Jilore. A daily catch rate of 12 oz. was found by van Someren (1959) in an upper tributary of the Tana using basket-traps, again showing the inefficiency of this method.

From all available records at Jilore, a total of 15,876 man-days were recorded in nine months. August and September, 1954, which were not recorded, were hardly fished at all, but October and November, 1953, also not recorded, were heavy fishing months. It is estimated therefore that, with about 19,000 man-days of fishing, and with an average of two traps per man, there were 38,000 trap-days on the Jilore stretch of river. At 4.8 oz. per trap-day this part of the river probably yields about 11,600 lb. of fish a year. There are eight other main fishing areas between Kakoneni and the sea, so that river trapping produces about 100,000 lb. of fish annually.

Catch rates for baskets are higher in the *ziwas*. During 69 recorded fishing days, a single basket placed in one of the Jilore *ziwas* yielded 135 lb. 2 oz. or 1 lb. 11 oz. per day. Allowing four months in the year when the *ziwas* are either dried out or fished out, the yield for the remaining eight months would be in the region of 350 lb. In the case of the Jilore *ziwas*, the area fished by the experimental trap was about an acre. In fact at least two traps are used in each *ziwa*, so that the *ziwas* probably produce the high yield of 700 lb. per acre. Total yield from all the *ziwas* is difficult to estimate since the area of the *ziwas* varies from year to year depending on the extent of flooding. A conservative estimate might put the area of *ziwas* in this 20-mile stretch of river at about 300 acres, so that the *ziwas* may produce up to 200,000 lb. per year.

Of the streams in this area, only the Koromi was recorded in any detail, the effort on other streams being extremely sporadic. During the survey there were as many as 28 *uchigo* on the lower Koromi, but only about half that number were used consistently. While the larger *uchigo* employed up to 15 basket traps, an average of five traps per *uchigo* was recorded for the lower Koromi. Catch rates for the baskets recorded gave a daily yield of 1 lb. 2 oz. per basket, and just over 200 actual fishing days were recorded in a year. It is estimated therefore that the Koromi river produces about 15,000 lb. of fish per year.

On the larger lakes the catches are high owing to the numbers of large *Clarias* and *Protopterus* caught on long lines. Unfortunately, time did not allow for detailed recording of lake catches, but from the records that exist it is clear that Lake Chem Chem is the most productive lake, producing about 150,000 lb. of fish a year. Records from Lake Mekimba indicate a yield of about 19,000 lb. per year. Lakes Kombeni and Mbrikano are considered roughly equal to Lake Mekimba, and Lake Merikano to the north of Kakoneni probably equals Lake Chem Chem, so that an estimate of 300,000 lb. from all the lakes is perhaps conservative.

The contribution that river prawns make is small. In November, 1953, Messrs. East African Fisheries Ltd. set up buying stations at Kakoneni and Matsangonjikoni (at the mouth of the Koromi river). In the first three months the industry did well, 1,362 lb. of prawns being bought at the two stations. In the next three months however, the amount of prawns dropped to 465 lb. and in May, June and July no prawns were bought at all at Kakoneni. Such a decline may have been partly due to the scarcity of prawns in the river, but was probably aggravated by a shortage of food and reluctance on the part of the fishermen to part with a protein crop. At Kakoneni 24 fishermen were selling prawns (at 75 cents per lb.) and between November and March an average of 1.48 lb. were sold per week by each man.

For the whole region therefore, fish production is small in comparison with areas such as Nyanza Province and it is estimated that no more than about 600,000 lb. or 300 tons of fish are produced annually.

THE DEVELOPMENT OF THE FISHING INDUSTRY

While fishing activities concentrate on extracting the last fish from the *ziwas*, which for the majority of species contain next year's stocks, and while the *ziwas* themselves rarely remain full until the next flood, then obviously no greater production of fishes can be expected. For the lakes also, it is doubtful whether a greater fishing effort could be sustained. On the other hand, the trapping of upgoing migrants in the streams, before they have reached the *ziwas* or lakes to spawn, is jeopardizing next year's potential stocks.

At the present time, river recruitment probably depends on the release of fry from those *ziwas* above Shakama which are unfished and which remain full until the next flood. River stocks could probably be increased by the setting aside of certain of the larger *ziwas* as nurseries where fishing would be prohibited. In addition, yields from the *ziwas* could be raised if a longer period were allowed before fishing commenced. Again, the area of the *ziwas* could be greatly increased by the construction of simple earth bunds, and in many cases water could be retained longer, since most of the lower *ziwas* discharge back into the river directly the floods subside.

River fishes are still predominantly a food rather than a cash crop, mainly due to the very widespread sale of sea fishes, even as far inland as Kakoneni. River fishes, mainly sun-dried *Tilapia* on sticks (*Mbani*) are taken by bicycle to some of the smaller villages or to individual homesteads. It is doubtful whether the fishing industry will expand without a greater cash incentive, but this may be prevented by competition from the very much larger sea fisheries.

REFERENCES

Blanco, G. J. (1958). Assay of the goby fry (ipon) fisheries of the Laoag river and its adjacent marine shores, Ilocos Norte Province. *Phil. Jour. Fish. 4* (No. 1), 32.

Copley, H. (1958). Common freshwater fishes of East Africa. Witherby, London.

Greenwood, P. H. (1955). Reproduction in the Catfish, *Clarias mossambicus* Peters. *Nature, 176,* p. 516.

Johnels, A. G. (1954). Notes on fishes from the Gambia river. *Arkiv för Zoologi. 6* (17), 327-411.

Whitehead, P. J. P. (1958). Indigenous river fishing methods in Kenya. *E. Afr. agric. J., 24,* 111.

Whitehead, P. J. P. (1959A). The river fisheries of Kenya. 1.—Nyanza Province. *E. Afr. agr. J., 24,* 274.

Whitehead, P. J. P. (1959B). Notes on a collection of fishes from the Tana river below Garissa, Kenya. *J. E. Afr. nat. Hist. Soc., 23,* 167.

van Someren, V. D. (1959). A study of a small basket-trap river fishery in Kenya. *E. Afr. agric. J., 24,* 257.

van Someren, V. D., and Whitehead, P. J. P. (1959). Records of young eels in Kenya rivers. *Nature, 183,* 950 and 971.

THE EFFECT OF POTASSIUM ON THE PRODUCTIVITY OF LUCERNE

By R. G. Poultney, The Grassland Research Station, Department of Agriculture, Kitale, Kenya

(*Received for publication on 29th May, 1959*)

It is well known that potassium is an important element in the nutrition of lucerne [1], [2] and [3]. Kenya soils in general are stated to be well supplied with potassium, though various laboratory tests have shown that this element may be in short supply in some of the lighter coloured and lighter textured soils found in the basement-complex areas [4].

The soil at Kitale is derived from the basement-complex and it is one of the few soils that might be expected to respond to fertilizer potassium. Accordingly from 1955-57, an experiment was carried out on the Grassland Research Station, Kitale, to test this possibility.

Row planted lucerne was used as the test crop in a 3×3×3 factorial experiment, in which the following fertilizers were applied at planting: potassium sulphate at 2, 4 and 6 cwt. per acre, calcium carbonate at 5, 20 and 50 cwt. per acre, triple supherphosphate at 1, 2 and 3 cwt. per acre. This latter fertilizer was thereafter applied annually at the beginning of the growing season.

The lucerne was sampled whenever it had reached the early flowering stage of growth and its yield of dry matter was determined at each harvest. The mean yields of dry matter produced during the course of the experiment are given in Table I.

DISCUSSION

It is apparent from the results shown in Table I that the linear increase in the yield of dry matter—25 cwt.—which was significant at the one per cent level, resulted from the increased rate of application of potassium sulphate from 2 cwt. to 6 cwt. per acre. None of the interactions between this fertilizer and the calcitic or phosphatic fertilizer were significant.

The main effects from the application of calcium carbonate and of triple superphosphate respectively were not significant.

In view of the low yields of lucerne frequently encountered on the basement-complex soils of the Trans Nzoia it may well be that a shortage of potassium in these soils is a factor limiting the production of this crop. The results reported here would strongly support this view. Parenthetically, it may be argued that if these soils are marginal for sulphur also, then the sulphur contained in the potassium sulphate may be a factor contributing to these results for lucerne. This, however, is a matter yet to be determined, though it may be appropriate here to state that the effect of applying gypsum sulphur to lucerne growing on this Station has been so far extremely variable.

CONCLUSION

It has been shown that the yield of lucerne, grown on the Kitale soil, can be increased substantially by an application of 6 cwt. per acre of potassium sulphate.

REFERENCES

[1] Hunter, A. S., Toth, S. J., Bear, F. E. (1943). *Soil Sci., 55,* 61.
[2] York, Jr. E. T., Bradfield, R., Peech, M. (1953). *Soil Sci., 76,* 481.
[3] Wallace, A., Bear, F. E. (1949). *Plant Physiol., 24* 664.
[4] Bellis, E. Private Communication.

TABLE I.—DRY MATTER YIELDS OF LUCERNE, 1955–57 (*cwt. per acre*)

	CALCIUM CARBONATE			TRIPLE SUPERPHOSPHATE			Mean
	5 cwt.	20 cwt.	50 cwt.	1 cwt.	2 cwt.	3 cwt.	
POTASSIUM SULPHATE—							
2 cwt.	74	77	85	75	86	75	79
4 cwt.	90	91	88	81	97	91	90
6 cwt.	99	99	113	106	95	110	104
CALCIUM CARBONATE—							
5 cwt.				88	91	85	88
20 cwt.				92	98	78	89
50 cwt.				82	89	113	95
Mean				87	93	92	91

Yield of control=65 cwt. C. of V.=14·6 per cent.

Significant Responses

	5%	*1%*	*0·1%*
Interactions	25	35	49
Main effects	15	20	28

CONCERNING THE PROPOSED INTRODUCTION OF NILE PERCH INTO LAKE VICTORIA

By G. Fryer, East African Fisheries Research Organization, Jinja, Uganda

(*Received for publication* 11*th September*, 1959)

The ultimate aim of those Government Departments concerned with natural resources and also of many private individuals in East Africa is to increase the productivity of the land and waters of this part of the Continent. One strongly mooted suggestion whereby this may be accomplished in Lake Victoria is by the introduction into its waters of the Nile perch *Lates niloticus* (L) or one of its reputed subspecies. This well-known fish has in its favour the fact that it grows to a large size (maximum weight recorded, 360 lb.), is extremely palatable, and is an excellent sport fish. Further, proponents of its introduction argue that, as it coexists with species of *Tilapia* in other lakes such as Albert and Rudolf, it would do no harm to the present *Tilapia* fishery on which commercial production from Lake Victoria so largely depends, and that it will in fact utilize the vast numbers of *Haplochromis* which occur in the lake but which, in general, are too small to merit commercial exploitation on any but a subsidiary scale. It has also been pointed out that to stock the lake with this fish would in fact be a reintroduction and not an introduction, for fossils of *Lates* have been found in Miocene deposits on Rusinga Island—showing that members of this genus occurred in Lake Victoria at this time. Why then should the introduction of the fish be opposed?

Before considering any scientific principles it is as well to recall the often disastrous effects of animal introductions in various points of the world. Many examples are too well known to call for comment but one particularly pertinent case merits attention here. In North America the opening of a route by which the sea lamprey could enter the Great Lakes has had such disastrous consequences that the lake trout, which was formerly the basis of a flourishing commercial fishery, has been so reduced in numbers as to extinguish completely this valuable industry. To quote figures for one lake only, in Lake Michigan a steady yield of 6,000,000 lb. of lake trout per year was obtained as recently as the early 1940's (Hile, Eschmeyer and Lunger, 1951). Of this amount over 2,000,000 lb. came from that part of the lake which lay within the State of Michigan. By 1956 and 57, however, the lake trout did not figure at all in the lists of commercial catches from this part of the lake. (State of Michigan Department of Conservation 1959.) The Lake Huron fishery for lake trout had previously been eradicated in less than 20 years. This example alone should serve as a warning against the random dispersal of the Nile perch.

Arguments centred on the question of Nile perch introduction have so far been at an empirical level. Concrete facts seem to be almost completely lacking and such scientific data as have a bearing on the question seem to have been ignored or, one suspects, are unknown to proponents of the idea.

Ecology is a complex subject and the elucidation of the interaction of one animal with the other members of the community in which it lives constitute some of its most complex problems. These call for the application of more than empirical knowledge. Moreover as the fishery of Lake Victoria is worth several million pounds annually and is of incalculable worth as a source of protein to the indigenous population it behoves those responsible for its continued prosperity to give attention to the information which science can provide and to take heed of the advice which it has to give.

It is, however, just as much a dictate of common sense as a scientific principle that predators can never be as abundant as non-predators. The Chinese proverb that one hill cannot shelter two tigers shows that this elementary fact has long been appreciated, and the fact that only small numbers of lions (or weasels) exist in comparison with large numbers of small antelopes (or rodents) must be obvious to the least observant. Because of this principle a biologist would not expect to see great catches of Nile perch if this fish were introduced into Lake Victoria but the landing of heavy catches of *Tilapia* (which fulfils a role in the lake somewhat akin to that of the grazing mammals on the land) is a not unexpected phenomenon. This brings us to a very simple scientific concept; the so-called pyramid of numbers or Eltonian Pyramid, long appreciated by biologists but first given concrete expression by Elton. Simply expressed this principle states that animals comprising the lowest levels of a food chain, i.e. those which feed on plant matter, occur in the largest numbers, and that the further they are removed from this stage, i.e. the more carnivorous they are, the fewer they are in numbers.

Very obvious illustrations of this have been given above but lest it should be thought that refuge is being sought in a purely theoretical concept so far as fisheries are concerned reference may be made to the study of Carlander (1955) which in itself should condemn the idea of Nile perch introduction for ever. Carlander studied the standing crops of fishes of various species in numerous North American lakes for which detailed figures were available. He then arranged the species concerned in three groups—those which are the end points of short food chains; the insectivorous fishes, which terminate somewhat longer food chains; and the secondary predators which represent the culmination of the longest food chains. Members of the first group were found to have high standing crops, of the second somewhat lower standing crops, and of the last low standing crops. This is shown in the accompanying graph which has been prepared from Carlander's figures. For simplicity only a selection of the fishes with which Carlander dealt are included in the graph and, in order that an unbiased comparison can be made, only the three species with the highest mean standing crops in each group are considered. The highest absolute standing crops were 1,016, 292 and, in the long food-chain species, 84 lb. per acre respectively.

Further condemnation of the project is called forth when one considers conversion rates. These have been understood in principle by simple husbandmen from the earliest times, yet the would-be introducers of the Nile perch are apparently unaware of their significance for they would embark on a scheme which has no parallel in animal husbandry. Farmers concentrate on the rearing of herbivores; the rearing of carnivores is never considered. Concrete data showing why this is so are available. In a now classical study Lindeman (1942) was able to place the concept of the Eltonian Pyramid on a quantitative basis by dealing with the biomass rather than with absolute numbers of the organisms concerned in such a pyramid, and was able to work out rates of production and to express them as units of chemical energy fixed and handed on from one trophic level to that next above it. As he worked with lacustrine communities his studies are particularly relevant to the present question. He calculated that the primary consumers (the herbivores) were about 13 per cent efficient in utilizing plant matter, and that the secondary consumers (the carnivores) were about 22 per cent efficient in utilizing the herbivores. As more recent work has shown that these figures are rather higher than is general we can for convenience regard them as 10 per cent and 20 per cent and this means that the energy reaching the carnivores is only 2 per cent of that originally available. Considering these figures Deevey (1958) remarks "We see at once why meat costs more than corn. For the same reasons the management of lake fisheries for pickerel or lake trout is an uneconomical luxury; this is an inefficient way to 'grow protein'". Consideration of these figures emphasizes, if emphasis is necessary, that the population of the predator must be very much smaller than that of the prey species. Lest these figures be considered too theoretical a remark by Carlander (1958) is worthy of quotation. "Studies on farm ponds and on food conversion indicate that there should be about 5 lb. of forage fish for each

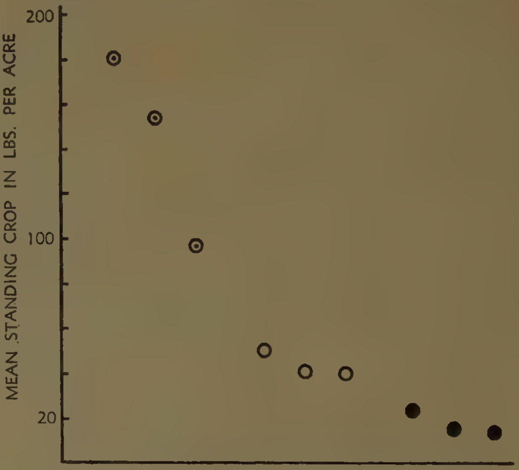


Fig. 1.—Mean standing crops of fishes of three feeding groups in North American lakes. Dotted circles: Short food chain fishes. Open circles: Intermediate food chain fishes. Solid circles: Long food chain fishes. (Note: The minimum number of lakes considered for any species is 7. In all other cases 21-64 lakes and reservoirs are considered. In group two one figure refers to several species of sunfishes with similar feeding habits.)

(Prepared from data in Carlander, 1955.)

pound of predator." This is hardly a recommendation for the introduction of the Nile perch for surely 5 lb. (or even 2 lb.) of *Tilapia* is preferable to 1 lb. of Nile perch.

These figures serve also to introduce another important but much less evident point. Let us for a moment assume that we are dealing with a single Nile perch weighing 200 lb. and that this fish has fed exclusively on *Tilapia* weighing 1 lb. each. At the above conversion rates it must have consumed 1,000 such fish. Now, in a gill net fishery in which nets are set at random the chances of catching a single Nile perch would be the same as those of catching a *Tilapia*. If only 50 per cent of the *Tilapia* were cropped the yield would be 500 lb. of fish, and if the Nile perch were present in their stead the chances, at this level of fishing intensity, would be only one in two of catching a single 200-lb. fish. If only half of the food of the Nile perch was provided by *Tilapia* these fishes would yield, at 50 per cent exploitation, 250 lb. of fish (plus a certain weight of the other prey species). Set this against a 50-50 chance of catching only one 200-lb. Nile perch and another cogent reason for not introducing this predator is obvious.

Proponents of introduction hold that the Nile perch would feed mainly on the *Haplochromis* species which abound in the lake. This is wishful thinking. That some *Haplochromis* would be eaten is highly probable, but it would be foolish to rely on the possibility of these fishes forming the main food of the Nile perch. The disparity in size between the Nile perch and the species of *Haplochromis* is such that the great effort involved in catching an adequate number of these small fishes may well prejudice the larger specimens of *Lates* against them and stimulate a search for larger prey. That such larger prey, including *Tilapia*, is taken by the Nile perch has been known for many years for Worthington and Ricardo (1936) record remains of *Tilapia* up to 25 cm. in length in the stomach of one of the Lake Rudolf subspecies. The hypothetical figures quoted above show that even if 50 per cent of the food of the Nile perch were provided by *Haplochromis* this fish would still be an uneconomical producer of protein for human consumption.

That the supply of *Haplochromis* is being utilized by existing fishes in Lake Victoria has now been made abundantly clear by Corbet (1959) who has shown that *Bagrus* and *Clarias* feed extensively on these fishes and scarcely touch the commercially important *Tilapia*. If it is desired to increase this indirect exploitation of *Haplochromis* it would seem reasonable to concentrate on finding means of encouraging the predators already present, of which *Bagrus* in particular is a valuable food fish, rather than introduce a fish which may or may not utilize these fishes and may or may not feed on the valuable *Tilapia*. There is also the possibility that the Nile perch would feed to some extent on *Bagrus* and *Clarias* and this would have further undesirable consequences.

It is as well to recall at this juncture that the suggestion that the Nile perch should be introduced into Lake Victoria runs contrary to accepted principles of fishery management which, save in cases where small lakes contain "trash fish", seeks usually to remove and not introduce predators. In fact as Ricker (1952) states "There is a growing interest in the control of predators as a tool in fishery management", and encouraging results have been obtained in North American lakes as a result of such control, *see* Smith (1952).

It has been suggested that research shortly to be initiated on the Nile perch may show how it will "fit in" if introduced into Lake Victoria. While our ignorance of the biology of this fish is such that any information that can be collected will be welcomed for its own sake, I maintain that the results of this research, valuable as they may be in the correct context, will be of little use in determining the behaviour of the Nile perch should it be introduced into Lake Victoria. I suggest that no matter how much information from other lakes becomes available no conscientious biologist would ever be prepared to claim that he could predict accurately the behaviour of the Nile perch after such a transfer. Differences in behaviour patterns of the same animal species when placed under different sets of circumstances are well known and are impossible to predict with certainty. To quote a very pertinent example, the herbivorous fish *Tilapia zillii* (Gervais) has recently been introduced into Lake Victoria. On the face of it this species would appear to be ideally suited to the filling of a completely unexploited niche (weed eating) in the lake and might be expected to in no way interfere with the indigenous species. Recent work (Fryer unpublished) has, however, revealed a completely unanticipated interaction between this species and one of the indigenous species of *Tilapia*, and one which could conceivably have far-reaching consequences in the future. By the same token the suggestion that "pilot introductions" into small lakes will serve as a pointer to the behaviour of the Nile perch in Lake Victoria should it be introduced is nonsensical. No two lakes are alike either as a whole or in any one of innumerable respects and the information gained from such an introduction would be of little value in determining the role of the Nile perch in other lakes. Where for instance, to raise a single concrete objection, can one experiment in a small lake which contains such a complex association of *Haplochromis* species as Lake Victoria; fishes which, according to would-be introducers of the Nile perch, would form the main food of this species should it be introduced into the lake? It is therefore a matter for regret that some such "pilot introductions" have already been made. Others should be forbidden.

One other point deserves brief mention. It is now a well-known fact that the cropping of many fish populations results in increased growth rates, and therefore yield, of the survivors, and the cropping of *Tilapia* by Nile perch may be thought to have this beneficial effect. For two reasons this would be a false surmise. First the *Tilapia* stock is already adequately (or more than adequately) cropped by man. Second, cropping of many fishes affects the growth rate of the survivors by reducing the demand on a given food supply, but this beneficial effect is not likely to be noticeable in the case of the *Tilapia* species of Lake Victoria for, even when population densities are high, the supply of food (phytoplankton) is hardly likely to be limiting.

It is sincerely hoped that such facts as these will receive due consideration from those who would contemplate, by reintroduction of the Nile perch, a reversal of the fortuitous event which, in the distant past, led to the extinction of this fish in Lake Victoria.

SUMMARY

The suggestion that the fishery in Lake Victoria would benefit if the Nile perch (*Lates niloticus*) were introduced into the lake is shown to be based on ignorance of several fundamental biological concepts. Both theoretical reasoning and practical experience strongly suggest that such an introduction is not only undesirable but would jeopardize the existing commercial fishery.

REFERENCES

Carlander, K. D. (1955). The standing crop of fish in lakes. *J. Fish Res. Bd. Canada. 12*: 543.

Carlander, K. D. (1958). Disturbance of the predator prey balance as a management technique. *Trans Amer. Fish. Soc., 87*: 34.

Corbet, P. S. (1959). The food of non-cichlid fish in Lake Victoria. *E. Afr. Fish Res. Org.* Ann Rep. for 1958, p. 21.

Deevey, E. S. (1958). The equilibrium population. In *The population ahead.* Ed. R. G. Francis. Univ. Minnesota Press.

Hile, R., Eschmeyer, P. H. & Lunger, G. F. (1951). Decline of the lake trout fishery in Lake Michigan. *Fish. Bull. Fish Wildlife Serv. 52*: 77.

Lindeman, R L. (1942). The trophic-dynamic aspect of ecology. *Ecology. 23*: 399.

Ricker, W. E. (1952). Numerical relations between abundance of predators and survival of prey. *Canad. Fish Cult.* No. 13, 5.

Smith, M. W. (1952). Fertilization and predator control to improve trout production in Crecy Lake, New Brunswick. *Canad. Fish Cult.* No. 13. 33.

State of Michigan Department of Conservation (1959). Nineteenth biennial report, 1957-58. Fish and fisheries divsion: 57.

Worthington, E. B. & Ricardo, C. K. (1936). Scientific results of the Cambridge Expedition to the East African Lakes, 1930-1, No. 15. The fish of Lake Rudolf and Lake Baringo. *J. Linn. Soc.* (*Zool*). *39*: 353.

SHARKS OF THE WESTERN INDIAN OCEAN—III

CARCHARINUS MENISORRAH (MULLER AND HENLE)

By J. F. G. Wheeler, East African Marine Fisheries Research Organization, Zanzibar

(*Received for publication on 16th September, 1959*)

Among the many species of typical sharks assembled under the genus *Carcharinus* one stands out by reason of a black-tipped second dorsal fin contrasting strongly with a pale grey body. This is *C. menisorrah*, one of the commoner sharks of the coast which is not believed to grow much more than one metre in length.

In Muller and Henle's description of *menisorrah* (1841) the colour is given as ash-grey above, yellowish-white beneath, no markings: and in Klunzinger's account (1871) the body colour is said to be blackish-grey, white beneath with the fins uniformly dark. Again, in Gunther's catalogue of fishes (1870) the colour is "uniform, fins with margins whitish". No mention is made of the black-tipped D II. It should be noted, however, that these authors were describing the colour and markings of preserved material or repeating the observations of others. Muller and Henle worked on dried specimens in the museums of Berlin, Leyden, Paris and London, as well as a foetus belonging to the Zoological Society and (presumably) another foetus in the Military Medical Museum at Chatham. Klunzinger's note is "from Ehrenberg's drawing" while Gunther's material consisted of two specimens from the Moluccas (one of which, at least, was stuffed), a type specimen of Bleeker's species *tjutjot*, considered synonymous with *menisorrah*, and "the jaws of a large example (12 in. wide)".

Day (1878-88) was the first to correlate the black-tipped second dorsal in fresh material with the distinctive teeth of the species and he explained the earlier neglect of the conspicuous external character by postulating its occasional absence. This may be so, but it has not come under our notice; and Blegvad (1944), who examined 561 specimens in the Persian Gulf, says—"our specimens always had a distinct dark spot on D 2". It appears more likely that desiccation reduced the contrasting blackness of the fin in the museum material and in consequence it passed unnoticed.

C. menisorrah was not seen by Playfair (1867) at the Seychelles nor by us on the banks and dependencies of the Seychelles (Wheeler and Ommanney, 1953) nor was it recorded from Zanzibar (Playfair and Gunther, 1866, Von Bonde, 1934). A painting by Nicolas Pike (*see* Gudger, 1929) of a shark called l'endormi in Mauritius was assigned to this species by Bliss in 1874. This shark was "about 5 ft. 11 in." Another "l'endormi" of 13 ft. 7 in. was assigned to *Carcharinus* sp.—again from a painting. "l'endormi" (the sleepy one) was the name appropriately attached to *Nebrius concolour* by our Seychellois crew during the Mauritius-Seychelles Survey. The record of *menisorrah* at Mauritius must be considered doubtful. It does not appear among the sharks of Southern Africa (Barnard, 1927, Smith, 1949). Blegvad (l.c.) reported that *C. menisorrah* was by far the most common shark in the Persian Gulf and from the fact that among his records there were very few that exceeded one metre in length he doubted Day's statement that the species "attains twelve feet or more". Measurements of Zanzibar specimens support Blegvad's contention.

Material

The following description is based on examination of eight males and four females ranging from 506 to 855 mm. all caught off Zanzibar. Two profile outlines were made with colour notes and the jaws were removed from both these specimens. The proportional measurements, expressed as percentages of of total length throughout, are given in the table appended.

Description

The body form is that of a typical Carcharinid shark (Fig. 1, A). The snout is moderately long, the nostrils midway between its tip and the point of the lower jaw. There are very small labial furrows extending outwards from the angles of the jaw (Fig. 1, B).

The upper teeth are single cuspid with serrations diminishing from the base to the point on both edges. They are obliquely set so that the inner edge is almost straight and the outer forms a re-entrant angle with the more heavily serrated basal ledge (Fig. 1, C). In my specimens there are 12-1-12 rows of teeth above and there are eight replacements of the central tooth visible. In the lower jaw the teeth are oblique at the same angle as the upper ones but are smaller, with slimmer, unserrated cusps. The outer shelf of the basal part is knobbed slightly. There are 12-12 rows in the larger specimen and 12-1-12 in the smaller. Day's count was 28 in the upper jaw, Gunther gives 27 to 28 in both jaws while Muller and Henle refer all anatomical details to *C. sorrah* with the exception of the more posterior placing of D I in *menisorrah*, its longer tail which results in a much greater distance from the pelvics to the anal than from the anal to the caudal and the non-serrated lower teeth. *C. sorrah's* dental formula is 25 above, 25 below.

The scales of *menisorrah* are five-keeled, with a strong middle point (Fig. 1, D) and are not very closely set. There is no sign of a ridge between D I and D II.

This shark is an inshore species. The males are sexually mature at about 850 mm. A foetus 240 mm. long collected by S. P. Rawlins, Esq., at Lamu, preserved in Formol alcohol, is still easily identified by the black tip to its second dorsal after nearly two years.

REFERENCES

Barnard, K. H., 1927. Monogr. Marine Fishes of South Africa II, *Ann. S.A. Mus. XXI.*

Blegvad, H., 1944. Fishes of the Iranian Gulf. Danish Scientific Investigation in Iran, Pt. III. *Copenhagen.*

Day, F., 1878-88. The Fishes of India. *London.*

Gudger, E. W., 1929. Nicolas Pike and his unpublished paintings of the fishes of Mauritius, Western Indian Ocean, etc., *Bull. Amer. Mus. Nat. Hist. LVIII, 9.*

Gunther, A., 1870. Catalogue of Physostomi etc. in the Collection of the British Museum, *London.*

Muller, I. and Henle, J., 1841. Syst. Beschr. der Plagiostomen, *Berlin.*

Playfair, R. L. and Gunther, A., 1866. The Fishes of Zanzibar. *London.*

Playfair, R. L., 1867. The Fishes of Seychelles, *Proc. Zool. Soc. Lond.*, pp. 864-872.

Wheeler, J. F. G. and Ommanney, F. D., 1953. Report on the Mauritius-Seychelles Fisheries Survey, 1948-49. H.M.S.O., *London*

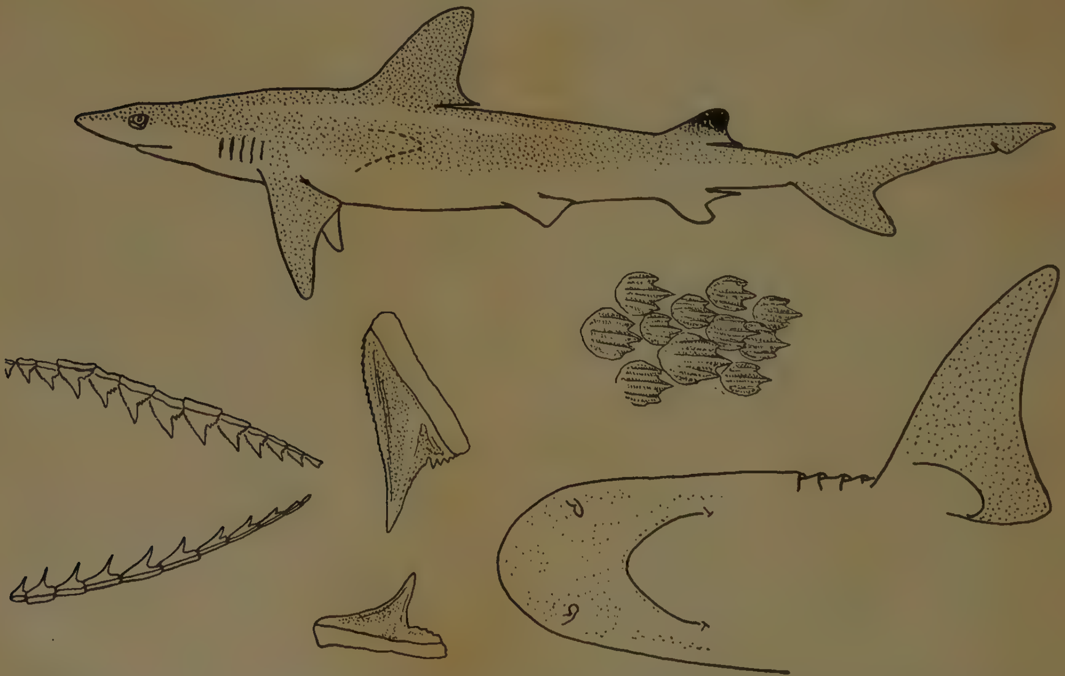


Fig. 1.—*Carcharinus menisorrah* (M. and H.). A. Profile outline of specimen drawn from average percentage measurements; B. Outline of lower surface of head drawn as above; C. Upper and lower teeth of left-hand side and 4th upper and lower tooth enlarged; D. Scales.

Carcharinus menisorrah (MULLER AND HENLE)

	F	M	F	F	M	F	M	M	M	M	M	M
Total length	506	540	580	585	595	595	623	635	655	767	850	855
Snout to caudal pit (dorsal)	72·9											
Snout to line joining ant. ends of nostrils	3·4	3·7	3·4	3·4	3·0	3·4	2·6	3·5	3·1	2·9	3·5	3·0
Snout to line joining post. ends nostrils	4·5	4·4	4·8	4·4	4·2	4·5	4·3	4·7	4·1	4·0	3·9	4·1
Snout to point of lower jaw	7·3	6·7	7·2	6·8	6·7	6·9	6·9	7·1	6·4	6·1	6·5	6·3
Snout to line joining angles of jaw ..	14·7	10·4	10·7	10·3	10·1	10·9	10·4	10·2	9·9	9·5	10·4	10·3
Snout to line joining 1st gill slits ..	15·4	14·4	15·8	15·4	15·1	15·4	15·2	16·2	15·0	15·4	15·9	15·8
Snout to line joining 5th gill slits ..	20·2	20·0	21·4	19·8	19·5	20·2	19·7	19·8	18·3	19·8	20·7	19·9
Snout to insertion of pectoral	19·4										20·0	
Snout to axilla of pectoral	23·1	21·9	24·8	23·4	23·0	24·5	24·1	22·8	21·4	23·5		23·2
Snout to origin of D.I.	28·9	26·3	29·3	28·4	28·6	29·4	28·3	28·3	29·0	27·4	28·8	28·7
Base of D.I.	8·3	9·3	9·0	8·5	9·4	8·4	9·2	8·8	7·6	9·1	8·2	9·0
End of D.I.	4·3	4·1	4·5	4·1	4·0	4·2	4·0	4·4	3·8	4·3	4·7	4·2
Height of D.I.	10·7	9·3	10·7	9·7	9·4	10·1	9·8	10·2	9·2	9·1	9·9	9·4
Snout to origin of D.II	58·9											
Origin D.I to origin D.II	29·8	33·3	31·0	31·6	30·6	32·0	32·1	31·5	30·5	33·0	33·8	33·3
Base of D.II	5·1	4·6	5·2	5·1	5·0	5·0	4·8	5·5	4·6	5·2	4·7	4·8
End of D.II	3·8	3·7	3·4	3·6	3·5	3·7	3·5	3·1	3·8	4·0	4·5	4·7
Height of D.II	4·0	3·7	4·0	3·8	3·7	4·0	4·0	3·9	3·1	4·2	4·0	3·9
Origin D.II to dorsal caudal pit ..	14·2	14·8	14·1	14·5	14·3	14·3	14·4	14·2	13·7	15·1	14·1	13·6
Free end D.II to dorsal caudal pit ..	5·3											
Dorsal edge of caudal (straight) ..	27·1	25·9	27·6	27·4	27·7	26·1	26·0	27·4	26·0	26·1	25·3	23·6
Caudal pit dorsal to notch	9·1	8·9	8·6	8·9	8·4	8·4	8·3	8·7	8·4	8·3	8·2	8·2
Caudal pit ventral to notch	8·1	8·2	7·9	7·7	8·4	8·1	8·0	8·3	7·9	7·8	7·6	7·0
Trans. width of dorsal lobe from notch	7·1											
Ventral pit to tip ventral lobe	12·1	11·5	12·1	12·0	11·3	12·1	11·6	12·0	11·1	9·4	11·8	11·1
Ventral pit in advance ventral pit ..	0·4											
Snout to insertion of pelvics	44·5	44·4	44·8	43·6	43·7	46·0	45·0	43·0	44·3	43·5	48·2	46·8
Anterior edge of pelvics	6·3	6·5	6·7	6·8	6·7	6·4	6·4	6·3	6·2	6·1	7·1	6·7
Post. edge (median) pelvics	2·4	3·7	2·8	2·7	2·7	3·0	2·9	2·7	2·3	2·6	3·3	2·7
Free post. edge pelvics	4·5	4·4	4·5	4·6	4·6	5·0	4·8	5·5	4·6	5·5	4·9	5·3
Snout to origin of anal	58·3	58·3	60·9	58·5	57·6	61·3	59·4	58·3	59·5	60·0	64·7	63·2
Base of anal	5·3	5·6	5·2	5·1	5·0	5·9	5·6	4·7	5·3	4·8	4·7	4·3
End of anal	3·6	3·3	4·0	3·1	3·4	3·4	3·2	3·9	3·5	3·9	4·1	4·0
Height of anal	3·6	3·7	3·4	3·4	3·2	3·0	3·7	3·3	3·1	3·7	3·5	3·5
Origin anal to ventral caudal pit ..	13·6	15·2	13·8	13·3	14·3	13·4	13·7	13·4	13·7	13·7	13·0	12·9
Free end anal to ventral caudal pit ..	4·7											
Anterior edge of pectoral (straight) ..	14·8	14·4	15·5	14·5	13·9	14·3	16·1	14·7	14·5	13·3	14·7	13·5
Greatest width of pectoral	8·3	8·2	8·6	8·0	7·9	8·4	8·3	8·8	8·2	8·7	8·2	9·1
Base of pectoral	5·3											
Depth of body at D.I	13·8	9·3	11·2	11·1	10·9	11·4	11·2	11·0	10·7	11·7	13·8	11·7
Snout to point of pectoral laid back ..	35·0											
Length of 3rd or longest gill slit ..	3·0	2·4	3·1	2·7	2·7	3·0	2·9	2·8	2·3	2·6	2·9	2·9
Largest diameter of eye	1·8								1·4	1·0	1·4	1·5
Largest diameter of orbit	2·4	2·2	2·2	2·4	2·4	2·2	2·3	2·2				
Distance between ant. ends nostrils ..	6·9	6·5	6·9	6·8	6·2	6·7	6·6	6·5	6·2	6·0	6·5	6·3
Width of head at eyes	9·5	8·3	9·5	9·4	8·9	9·2	9·3	9·1	8·9	9·1	9·1	9·0
Snout to centre of eye	7·9	8·2	8·6	7·7	7·6	7·7	7·5	7·9	6·7	7·0	7·6	7·4
Distance between post. ends nostrils ..	4·7	4·4	5·2	5·0	4·5	4·2	4·0	4·9	4·3	4·2	4·7	4·2
Distance between angles of jaw ..	6·3	5·6	6·0	6·2	6·1	4·2	4·5	6·3	6·2	6·1	6·1	6·2
Width of head at gape	10·3	9·3	10·3	10·3	10·3	9·8	9·8	9·8	9·8	9·5	10·0	10·1
Insertion of pectoral to origin of pelvics	26·5	25·9		40·2	39·5	39·0	39·0	55·9	41·2	43·0	28·8	44·9
Origin of pelvics to origin of anal ..	14·2	15·4	14·7	14·5	15·1	15·0	18·0	15·0	15·3	17·0	17·0	17·0
Length of claspers		2·8			3·4		3·2	3·5	3·8	3·9	10·6	11·5

Whatever the crop Whatever the weed–

you will find
the **right** selective weedkiller
in the **M&B** range

*'**PLANOTOX**' *brand of 2:4-D*

For killing weeds in maize, sugar cane, wheat, barley, winter oats, and grassland at low cost.

Gives better control of Wandering Jew, Pigweed, Blueweed, Horseweed, and Stramonium.

*'**EMBUTOX**' *brand of 2:4-DB*

For safe weed control in seedling lucerne and white clover seed crops.

*'**SPONTOX**' *brand of 2:4-D/2:4:5-T*

An effective brushwood killer for controlling Sodom apple, Euclia, Lantana, Acacia thorn bushes, Bramble, Gorse, and many herbaceous weeds.

'Spontox' is harmless to grasses.

Detailed information is available on request.

M&B BRAND AGRICULTURAL PRODUCTS

MANUFACTURED BY
MAY & BAKER LTD DAGENHAM · ENGLAND

Branch Office:
MAY & BAKER LTD · P.O. BOX 30104 · NAIROBI · TEL: 58870

* trade mark

HA1156

FILED IN STACKS

*Powerful 'bite'
on soft ground but stands
up to heavy wear on
hard roads.....that's the*

DUNLOP

RT35 "UNIVERSAL"

Agricultural Tyre

**Depositaires:—THE AFRICAN MERCANTILE
COMPANY (OVERSEAS) LIMITED**

(Incorporated in England)

Branches throughout Kenya and Tanganyika

PRINTED BY THE GOVERNMENT PRINTER, NAIROBI

REC LIB
OF HAWAII

EAST AFRICAN AGRICULTURAL JOURNAL

CUMULATIVE INDEX

VOLUMES

21-25

N.B.—The bold figure in each numerical reference is the volume number

Le Roux, J. G. 22.142
Leutenegger, F. 22.81
Lionnet, J. F. G. 24.254
Lloyd, J. H. 24.26
Long, R. P. 22.3
Lowe, Rosemary, H. 21.45
Luckham, M. E. 25.97

Macfarlane, J. S. 24.148
McKinlay, K. S. 22.20, 25.28
Maeda, N'Kella 23.273
Maitai, W. H. 23.290
Malherbe, Yvonne 21.20
Mesmer, E. T. 23.130, 23.199
Michelmore, A. P. G. 21.65
Millbank, J. W. 22.73
Milne, A. H. 21.2
Morgans, J. F. C. 25.91

Newell, B. S. 22.118, 23.113, 23.127
Nichol, D. A. 25.53
Nitrate Corporation of Chile, Ltd. 22.182
N'Kella Maeda 23.273

Ofield, R. J. 25.220

Parsons, D. J. 23.167
Passmore, R. G. 25.220
Peers, A. W. 23.228, 25.23
Pelley, R. Le 21.22, 22.115
Pereira, H. C. 22.57, 22.188, 23.246, 25.59
Petrides, G. A. 23.265, 25.50
Pfeiffer, R. K. 23.25
Poultney, R. G. 25.47, 25.266

Rapley, R. E. 21.210
Rensburg, H. J. van 21.169, 22.14, 23.190, 24.64
Robinson, J. 22.142, 23.130, 23.199
Robinson, J. B. D. 21.69, 22.76, 24.184, 24.192
Robinson, R. A. 22.130, 24.240, 25.131, 25.132
Robertson, A. G. 23.254
Robertson, I. A. D. 23.172
Rocco, D. M. 23.262
Rogerson, A. 21.159, 21.161, 21.163
Ross, J. G. 23.193
Roux, J. G. Le 22.142
Russell, E. W. 23.1

Salmond, K. F. 21.148
Sapiro, M. L. 25.126
Savile, A. H. 23.228, 24.1, 24.79
Schoenmaekers, J. 25.25
Scott, G. R. 22.168
Sheffield, F. M. L. 21.10, 22.70, 25.16
Sideek, O. Eff. 23.203

Smith, F. G. 23.119
Smith, R. G. 21.230
Someren, G. R. Cunningham van 23.29
Someren, V. D. van 24.257, 25.42, 25.66, 25.169, 25.245
Soper, J. R. P. 22.34
Strang, R. M. 23.100
Strange, R. 24.92, 24.171, 24.203, 25.251

Talbot, F. H. 22.118
Tanner, R. E. S. 21.120, 24.37, 24.70
Tapley, R. G. 23.82
Thomson, W. E. F. 23.186
Thorpe, H. C. 21.61, 21.164, 21.218, 22.183, 23.228, 24.15, 24.268
Tidbury, G. E. 21.53
Trapnell, C. G. 25.207
Trought, T. E. T. 21.28
Trump, E. C. 25.18
Turner, D. J. 22.35

Vail, J. W. 23.100
Van Rensburg, H. J. 21.169, 22.14, 23.190, 24.64
Van Someren, G. R. Cunningham 23.29
Van Someren, V. D. 24.257, 25.42, 25.66, 25.169, 25.245
Vink, H. H. J. de 21.69
Visser, S. A. 25.86

Wain, R. L. 23.22
Walker, G. F. 21.53
Walker, G. W. 21.2
Walker, P. T. 23.74, 25.165
Wallace, G. B. 21.25, 21.42
Wallace, Maud M. 21.25, 21.42
Wallis, A. N. 22.186
Wasawo, D. P. S. 25.86
Watkins, G. 23.74, 24.197
Wells, L. J. Collings- 23.228
Whalley, P. E. S. 23.110, 24.16
Wheatley, Susan M. 22.46
Wheeler, J. F. G. 25.106, 25.202, 25.271
Whitehead, A. G. 22.92
Whitehead, P. J. 24.111, 24.274, 25.42, 25.66, 25.169, 25.259
Wiley, A. J. 24.53
Williams, F. 23.113, 24.61
Williams, R. 25.18
Wilson, F. 23.38
Wilson, L. R. 22.24
Wilson, P. N. 23.138
Wolfe, Miriam 22.207
Wood, G. H. S. 21.34
Wooldridge, R. L. 24.237
Wright, W. A. 24.1

Yeo, D. 25.193

SUBJECT INDEX

Acacia seyal Del., The effect of Ring Barking and 2, 4, 5–T applied as a bark paint on 23.89
Acaracides, Toxicities of various, to mites of the Tetranychus complex in East Africa 25.28
Acid Fibre content of Lucerne in relation to its conventional Crude Fibre content at different stages of maturity 25.78
African Cultivator 22.34
African Farming, The development of .. 23.38
Agricultural Research in the Sudan Gezira 21.112
Agriculture, Subsistence, on the Tanganyika Coast 24.70
Aircraft in Central and East Africa, Locust Control by 24.26
Aluminium Phosphide for bulk Grain Fumigation in Uganda 24.103
Aluminium Silo in Tropical conditions, Storage of Maize in a Prefabricated .. 25.225
Ambrosia Beetle attack on logs, The control of 24.128
Ammonia and Nitrate contents of a Tropical Red Loam as influenced by Manuring and Mulching during a period of one year, Changes in 22.81
Animal Feeding Stuffs, Crude Fibre: Its Determination and its place in the Analysis of 21.225
Ankole/Aberdeen Angus three quarter crossed Bull bred at Whipsnade. The Conformation and characteristics of .. 24.269
Antibiotics as Dietary Supplements for Poultry 23.273
Arsenic Poisoning in Fowls, Malicious .. 21.20
Arthropods associated with stored Groundnuts in Nyasaland 21.148

Bacon Pigs, The Management of 23.149
Banana Weevil and its Control 23.110
Bark Diseases of Coffee, The 21.25
Barley, Maize and Oat Straws, Feeding Values of Local 21.159
Basket-Trap River Fishery in Kenya Colony, A study of a small 24.257
Bean Pests in Uganda, A note on the Control of 24.174
Bee Botany in East Africa 23.119
Bees, Carpenter (*Xylocopa* spp.) The use of Dieldrin for Control of 24.16
Bena Wattle Scheme.. .. .. .. 25.53
Bersama abyssinica, Stock Poisoning attributed to the leaves of the Shrub .. 25.63
Biological Control of Agricultural Pests in the Seychelles, A Review of 24.254
Black Wattle in Kenya, Some Pests of .. 21.230
Black Wheat beetle (*Heteronychus* spp.) in Kenya, Seed dressing against 25.23
Bloat, An experiment on the Control of .. 24.237
Borer Beetle, Laboratory observations on the Effects of Insecticides on the White Coffee 21.6
Boron Deficiency in Sisal (*Agave sisalana*, Perrine) 22.197
Breeding and Growth of Tilapia in Marine Fish Ponds on Zanzibar Island, A Preliminary Note on 22.118
Breeding Diseases of Cattle, Notes on Animal Diseases 23.211
Brewers Grains, Nutritive values of Locally prepared Pollards and Dried 21.161
Browse Plants of Kenya 23.236
Browsing and Reproductive Behaviour of the East African Dwarf Goat, Studies of the 23.138
Bush Clearing Experiments in the South Nyanza District of Kenya 25.31
Bush Clearing, Note on Mechanical .. 25.18
Butterfat Figures of the East Africa Milk Recording Scheme, The Reliability of .. 22.104

Camber Bed Cultivation of Ground Water (Vlei) Soils:
  I. Experimental Crop Yields .. 24.184
Camber Bed Cultivation of Ground Water (Vlei) Soils:
  II. Modification of the System .. 24.192
Camphor Forests, East African, of Mount Kenya 24.139
Cashew in Tanganyika, *Selenothrips rubrocinctus* (Giard) and the Floral Biology of 25.229
Cashew Nuts, Some Observations on the Germination and Grading of 22.35
Cashew Trees in Tanganyika, Sudden Death Disease of 21.42
Cassava Breeding for Virus Resistance, Further Studies in 22.213
Cassavas in Tanga Province, Tanganyika, Trials with Virus Resistant 23.135
Cattle of East Africa, The Zebu 21.83
Cattle, Spray Race Fluid, The Exhaustion of 22.88
Cattle, The Importance of Water in the Management of 21.171
Cattle Twins and their use in Research .. 22.113
Cattle, Variations in Liveweight of, on Farm and Ranch in Tanganyika.. .. 24.279
Cereal Crops, Notes on Kenya Agriculture I 23.228
Cereal Varieties—1955, Release of New .. 21.164
Cereal Varieties—1956, Release of New .. 21.218
Cereal Varieties—1957, Release of New .. 22.183
Cereal Varieties—1958, Release of New .. 24.15
Cereal Varieties—1959, Release of New .. 24.268
Chemical Factors limiting Growth of Phytoplankton in Lake Victoria 21.152

“Insack” Treatment of Maize with Insecticide for Protection against Storage Pests in Uganda 24.244
Insect Damage observed in Stored Groundnuts 22.106
Insect Pests, Food Storage Problems in Uganda in relation to 21.65
Insecticidal Spraying against *Glossina palpalis fuscipes* Newstead in the Nyando River Basin of Kenya, The Effect of .. 23.186
Insecticide Deposits applied to the Bark of Coffee Trees (*Coffea arabica*) I. D.D.T. Deposits, The Persistence of 23.130
Insecticides in Forestry and Agriculture, The Use of 23.74
Insecticides in Tropical Soils. Part I. Preliminary Investigations. The Persistence of 23.199
Insecticides on the White Coffee Borer Beetle, Laboratory Observations on the Effects of 21.6
Insects Associated with the Sweet Potato (*Ipomea batatas*) List of 23.290
Insects Attacking Maize on the Cob in Crib Stores. Control of 23.275
International Union of Forest Research Organizations 22.147
Irrigation—
  Experiments at the Coffee Research Station, Ruiru, Kenya 22.186
  of Coffee, The Seasonal Assessment of Water needs in 22.188

Johne’s Diseases Notes on Animal Diseases —XVII, Miscellaneous Diseases caused by Bacteria. Part II 23.224

Land Tenure in Northern Sukumaland, Tanganyika, An Analysis of Present-day Trends in Two Parishes 21.120
Land Use. Grain Yields in the Kenya Highlands 22.32
Land Use Map of Kenya 23.265
Land Use map of Uganda 25.50
Larvae of the Saturnidae (Lepidoptera), Notes on 22.220
Legume Inoculation 22.130
Legume Nodulation in Kenya. I. Exploratory Field Experiments 23.91
Legumes under Grazing, Preliminary Trials of Grasses and 24.92
Ley Grasses in Kenya, The Selection of Tropical 24.206
Leys, Temporary, The Effects of Four Management Treatments on 25.251
Livestock productivity in the Intensive Farming Areas of Uganda, Problems of Increasing 23.167
Liveweight of Cattle on Farm and Ranch in Tanganyika, Variations in 24.279
Live Weights in small Shorthorn Zebu Cattle from Linear Body Measurements. A Method of Estimating 23.193
Locust Control by Aircraft in Central and East Africa 24.26
Logs, The Control of Ambrosia Beetle attack on 24.128
Lucerne, Acid Fibre Content, of in relation to its conventional Crude Fibre Content at different stages of Maturity 25.78
Lucerne, A comparison between Russian Comfrey and 24.203
Lucerne, Chemical Weed Control in, by means of activated DNBP 23.262
Lucerne, Observations on the Growth of non-irrigated 24.171
Lucerne, The Effect of Potassium on the Productivity of 25.266

Machinery, Agricultural in East Africa .. 24.24
Magnesium Deficiency in East African Tea Bushes 25.25
Main Rains in Kenya, The Reliability of the 23.267
Mangoes of the Kenya Coast 22.46
Maize, An Experiment on Stem Borer Control on 21.220
Maize, and Oat Straws, Feeding Values of Local Barley 21.159
Maize, Effects of Population Density on Yield of 22.199
Maize, “Insack” Treatment of, with Insecticides for Protection against Storage Pests in Uganda 24.244
Maize on the Cob in Crib Stores, Control of Insects attacking 23.275
Maize, Palatability of, under Storage in Uganda 24.57
Maize Stalk Borer Control Methods in East Africa, A Survey of the Use of .. 25.165
Maize, Storage of, in a Prefabricated Aluminium Silo in Tropical Conditions .. 25.225
Maize, The Effects of, in Pig Rations .. 24.106
Maize, The Food Properties of Flint and Dent 24.251
Mastitis in Cattle. Notes on Animal Diseases XIX 22.127
Mechanical Bush Clearing, Note on .. 25.18
Milk Recording Scheme, East African, The Reliability of the Butterfat Figures .. 22.104
Milk Records of Leading Cows, East Africa:—
  December, 1954 to June, 1955 .. .. 21.77
  June, 1955 to December, 1955 .. .. 21.222
  December, 1955 to June, 1956 .. .. 22.107
  June, 1956 to December, 1956 .. .. 22.194
Mite, The Citrus Bud 21.22
Mites of the Tetranychus complex in East Africa, Toxicities of various acaracides to 25.28
Muninga (*Pterocarpus angolensis* D.C.) in the Western Province of Tanganyika—
  I. Descriptions, Distributions and Silvicultural characters 21.130
  II. Growth and Form Statistics .. 21.189
  III. Yields, Yield Control and Management 21.248
Mvule in Uganda in Relation to Soil-Root Conditions, Regeneration of *Chlorophora excelsa* 21.34

Nematodes, Plant-Parasitic—Important Pathogens in Tropical Agriculture .. 22.92
Nitrate and Ammonia Contents of a Tropical Red Loam as influenced by Manuring and Mulching during a period of one year, Changes in 22.81
Nitrogen in Tropical Soils 22.73
Note for Contributors to this Journal .. 22.136
Notes on Animal Diseases. List of:— 22.212
  I. Redwater and Anaplasmosis .. 25.10
  III. Piraplasmosis and Anaplasmosis of Animals other than Cattle and Trypanosomiasis of Domesticated Animals 25.147
  IV. Rinderpest 25.153
  XI. Virus Diseases of Pigs 22.168
  XIII. Rearing of Dairy Calves .. 22.3
  XVII. Miscellaneous Diseases caused by Bacteria. Part II Johne's Disease 23.224
  XIX. Mastitis in Cattle 22.127
  XX. Breeding Diseases of Cattle .. 23.211
  XXVII. Progressive (Enzootic) Pneumonia of Sheep in Kenya .. 21.207
  XXVIII. Some Aspects of Sheep Management 22.64
Notes on Kenya Agriculture—
  I. Cereal Crops 23.228
  II. Tabulated Recommendations for Manuring and Fertilizing in African Areas 23.234
  III. Notes on Oil Seeds, Pulses, Legumes and Root Crops in Kenya .. 24.1
  IV. Fruit and Vegetables 24.79
  V. Plantation Crops 24.153
  VI. Grass Leys and Plants 24.223
  VII. Insect Pests and Control Measures 25.2
  VIII. Important Plant Diseases .. 25.131
  Corrigendum—VI. Grass Leys and Grassland Plants 25.132
Nutritive Values of Locally prepared Pollards and Dried Brewers Grains .. 21.161
Nutritive Value of Pineapple Residues (dried) 21.163
Nutritive Value of Ramie Leaves (*Boehmeria nivae*), A Note on the 23.203

Oat Straws, Feeding Values of Local Barley, Maize and 21.159
Oemida gahani Distant (Cerambycidae), Notes on, Part II 22.224
Oxygen in Dams, The Nocturnal reduction of dissolved 23.127
Oyster, Edible East African, *Crassostraea cucullata* (Born), The Artificial Culture of 25.245

Palatability of Maize under Storage in Uganda 24.57
Pasture Grasses in Kenya, Observations on the Flowering of Exotic 24.142
Pasture Management in the Semi-Arid Areas of Kitui District, Reclamation and 23.84
Perch, Nile, Concerning the Proposed Introduction of, into Lake Victoria 25.267
Perkerra River Irrigation Scheme, Kenya, The Limited Utility of Flood Water in the 23.246
Pests—Agricultural, A Review of the Biological Control of, in the Seychelles .. 24.254
Pests of Black Wattle in Kenya, Some .. 21.230
Pests and Petroleum 21.108
Phytoplankton in Lake Victoria, Chemical Factors Limiting the Growth of 21.152
Phosphorus, Water Soluble, in some Local Feed and Faeces 25.188
Phytotoxic effects of Copper Fungicides on Acid Soils 24.125
Pig Rations, The Effects of Maize in .. 24.106
Pigs, The Management of Bacon 23.149
Pineapple replant areas, The Influence of Fertilizers 22.122
Pineapple Residues (dried), Nutritive Value of 21.163
Pine Plantations, Kenya, Dead Top in .. 24.47
Pine Seedlings, Sowing Density and Damping Off in 21.183
Pine Seedlings, Trials of Fungicides for the Control of Damping Off in 21.96
Pine Seedlings, Trials of Fungicides for the Control of Damping Off in II. Field Trials 21.165
Pines, Exotic, The effect of Depth of Planting at Muguga 22.175
Plant - Parasitic Nematodes — Important Pathogens in Tropical Agriculture .. 22.92
Ploughing Contest of 1956, World 21.182
Pollards—Dried Brewers Grains, Nutritive Values of Locally prepared 21.161
Polythene Bags, Sowing Seed in 24.197
Potassium, The Effect of, on the Productivity of Lucerne 25.266
Poultry, Antibiotics as Dietary, Supplements for 23.273
Poultry, The Rate of Growth and the Efficiency of Food Conversion in various Breeds 22.60
Prioninae (Coleoptera, Cerambycidae), New East African 23.49
Production of Kiln-dried Copra in the Tanga Province of Tanganyika 23.280
Progressive (Enzootic) Pneumonia of Sheep in Kenya, Notes on Animal Diseases XXVII 21.207
Protein Composition of some East African Seeds 22.207
Protein Content of Subsistence Crops in Uganda 24.67
Protein, The Digestible, of Ruminant Feeds by Calculation 24.33
Pterocarpus angloensis D.C. in the Western Province of Tanganyika, Muninga—
  I. Description, Distribution and Silvicultural Characters 21.130
  II. Growth and Form Statistics .. 21.189
  III. Yields, Yield Control and Management 21.248

Quarantine in East Africa, Plant .. . 21.10

Reviews—(*Contd.*)
  Weed Control Handbook, 1957 23.126
  West African Cotton Research Conference 25.224
  Wheat Production in Kenya, 1955–56. An Economic Study 23.160
  Year Book of Agricultural Co-operation, 1955 21.111
  Year Book of Fishery Statistics, Vol. IV, Part I, 1954 Supplement and Part II 21.219
  Yeasts 23.245
River Fisheries of Kenya Colony—I. Nyanza Province 24.274
River Fisheries of Kenya—2. The Lower Athi (Sabaki) River 25.259
Rosette-Resistant Groundnut Variety, *Asirya mwitunde*, A Study of 22.27
Ruminant Feeds by Calculation, The Digestible Protein of 24.33
Russian Comfrey and Lucerne, A Comparison Between 24.203
Rust Forms in East Africa. A Note on the Appearance of two New Stem 21.61
Sanga Cattle of East Africa 22.149
Saprophytic Fungi as Destroyers of Germinating Pine Seeds 22.203
Saturnidae (Lepidoptera) Notes on Larvae of 22.220
Sclerotium rolfsii Sacc. in Tanganyika, A Note on a Wilt of Groundnuts due to 22.137
Sea we Fish in, The 25.91
Seed Dressing against the Black Wheat Beetle (*Heteronychus* spp.) in Kenya 25.23
Seeds, Some East African, The Protein Composition of 22.207
Seed Sowing in Polythene Bags 24.197
Selenothrips rubrocinctus (Giard) and the Floral Biology of Cashew in Tanganyika 25.229
Serere Experiment Station, Uganda 1954–57. Herbage Plants at—I Grasses 24.41
Serere Experiment Station, Uganda 1954–57. Herbage Plants at—II Legumes 24.133
Shade Measurement by a Chemical Radiation Meter 25.110
Shark Products, Brief Notes on the Processing of some 21.167
Sharks of the Western Indian Ocean—
  I. *Loxodon macrorhinus* M. and H. 25.106
  II. *Triaenodon obesus* (Ruppell) 25.202
  III. *Carcharhinus menisorrah* (Muller and Henle) 25.271
Sheep, Hampshire Down, Supreme over all Breeds at Smithfield Show 22.174
Sheep of East Africa, The Fat Rumped 23.42
Sisal (*Agave sisalana* Perrine) A Boron Deficiency in 22.197
Sisal Waste, A Feeding Trial with 22.165
Skim-milk Feed, dried, Farm Preparation of 24.10
Slaughter Cattle, Use of Tranquilizers Prior to Transport of 25.73
Small Holdings on the Tanga Coast 24.37
Sodom Apple Control 25.214
Soils, acid, Phytotoxic effects of Copper Fungicides on 24.125
Soils of Zanzibar Protectorate, A study of the more Important 21.53
Soils, The Persistence of Insecticides in Tropical, Part I Preliminary Investigations 23.199
Some aspects of Sheep Management, Notes on Animal Diseases—XXVIII 22.64
Sorghum in Uganda, Experiments on the Control of Stalk Borers in 25.184
Sowing Density and Damping Off in Pine Seedlings 21.182
Stalk Borer Control Methods in East Africa, A Survey of the Use of Maize 25.165
Stem Borer Control on Maize, An Experiment on 21.220
Stock Poisoning attributed to the Leaves of the Shrub *Bersama abyssinica* 25.63
Stored Products in Uganda, Coleoptera associated with 25.199
Subsistence Agriculture on the Tanganyika Coast 24.70
Subterranean Clovers in Kenya, The Climatic Limitations of 24.121
Sudan Dioch (Quelea *Q. Aethiopica*) in Tanganyika, The Distribution and Breeding Behaviour of the 21.141
Sudan Dioch or Red Billed Finch (Quelea *Q. Aethiopica*) in Tanganyika, The Control of the 21.210
Sudden Death Disease of Cashew Trees in Tanganyika, A Preliminary Note 21.42
Sugar Cane Importation 25.16
Sugar Cane Ratoon Stunting—A Degeneration Disease of 22.70
Sugar Cane Smut 24.240
Sukumaland, Tanganyika, An Analysis of Present Day Trends in Two Parishes. Land Tenure in Northern 21.120
Swampworms and Tussock Mounds in the Swamps of Teso, Uganda 25.86
Sweet Potato (*Ipomea batatas*). List of Insects associated with the 23.290
Sweet Potato Tubers, The Feeding Value of 21.18

Take All Disease in Kenya Wheat, 131 Resistance to.
  II—Effect on Yield 21.32
Tea Bushes, East African, Magnesium Deficiency in 25.25
Termites, More about Dry—Wood 23.161
Termite Mounds, Fungus Combs in 23.104
Thrips Resistant to DDT, A Possible Case of Coffee 23.82
Tick, Common Brown, Distribution of, in Kenya 24.53
Tilapia nigra (Gunther) in Ponds, The Culture of—
  I. Growth after Maturity in male *T. nigra* 25.42
  II. The Influence of Water Depth and Turbidity on the Growth of Male *T. nigra* 25.66

    III. The Early Growth of Males and Females at Comparable Stocking Rates, and the Length/Weight Relationship 25.169
Tilapia in Marine Fish Ponds on Zanzibar Island, A Preliminary note on the Breeding and Growth of 22.118
Tilapia Species, The Fecundity of 21.45
Tobacco Eelworm Investigations in Uganda, Preliminary 21.28
Toxicities of various Acaracides to Mites of the Tetranychus complex in East Africa .. 25.28
Toxicological Analysis, Veterinary, Notes on 25.126
Trace Element Composition of some East African Feeding Stuffs, The Major and .. 21.103
Trace Elements in some East African Soils and Plants. I. Cobalt, Beryllium, Lead, Nickel, and Zinc in some Kenya Soils .. 25.121
Tranquillizers Prior to the Transport of Slaughter Cattle, Use of 25.73
Trichomoniasis, Notes on Animal Diseases XX. Breeding Diseases of Cattle, Part II 23.214
Tsetse Control Measure in Uganda, Game Elimination as a 23.254
Tsetse, Riverside, *Glossina palpalis fuscipes* Newst, Comparative Trials of DDT and Dieldrin for the Control of 22.142
Tussock Mounds, and Swampworms, in the Swamps of Teso, Uganda 25.86

Uganda, A land Use map of 25.50
Uganda, Problems of Increasing Livestock Productivity in the Intensive Farming Areas of 23.167

Veterinarian in World Economy, The Role of 25.80
Veterinary Toxicological Analysis, Notes on 25.126
Vibriosis, Notes on Animal Diseases—XX. Breeding Diseases of Cattle. Part III .. 23.218
Virus Disease of Pigs, Notes on Animal Diseases—XI 22.168
Virus Resistance, Further Studies in Breeding Cassava for 22.213
Virus Resistant Cassavas in Tanga Province, Tanganyika, Trials with 23.135
Vlei Soils, A Cultivation System for Groundwater 21.69

Wastage in the Herd 22.177
Water Hyacinth—now a "Prohibited Immigrant" 22.129
Water in the Management of Cattle, The Importance of 21.171
Water—Soluble phosphorus in some Local Feeds and Faeces 25.188
Wattle—a Boron Deficiency, Dieback of .. 23.100
Wattle Scheme, Bena 25.53
Weed Control Conference, African, Victoria Falls July 1958 .. .. 24.179
Weed Control in Lucerne by means of "Activated" DNBP chemical 23.262
Weevil and its Control, The Banana .. 23.110
Wheat 131 Resistance to Take All Disease in Kenya. II. Effect on Yield 21.32
White Coffee Borer Beetle, Laboratory Observations on the effects of Insecticides on the 21.6

Zanzibar Protectorate, A Study of the More Important Soils of 21.53
Zebu Cattle of East Africa 21.83
Zebu Cattle under Ranch Conditions, Variations in Gestation Periods of .. 24.148

G.P.K. 6282—1,400—11/60

IN STACKS

Printed
by
the
GOVERNMENT PRINTER, KENYA